AN INVESTIGATION OF CANCER MORTALITY IN BILLERICA, MASSACHUSETTS 1969-1985

The Massachusetts Department
of Public Health
Division of Environmental
Epidemiology and Toxicology
Community Assessment Unit
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Acknowledgements

The Massachusetts Department of Public Health would like to express their appreciation to the offices of State Senator Patricia McGovern, State Representative Michael Rae, and the concerned citizens of Billerica for their support and assistance throughout this investigation.

EXECUTIVE SUMMARY

At the request of Senator McGovern, Representative Rea, and a group of concerned citizens from Billerica, the Massachusetts Department of Public Health (MDPH) conducted an investigation of cancer mortality for the twelve major sites of cancer for the seventeen year period 1969-1985. This effort was part of a larger plan developed jointly by the MDPH and the Massachusetts Department of Environmental Quality Engineering (DEQE).

The purpose of this phase I investigation was to develop a health profile for the town of Billerica and to determine whether trends in elevations of certain types of cancer have existed over time and may warrant further attention.

The interest in health issues by citizens and government officials stems from concern over environmental contamination in and around the Iron Horse Park hazardous waste site. Much of the waste is contaminated with asbestos manufacturing waste products. Iron Horse Park was placed on the National Priority List in 1984.

The results of the Phase I investigation indicate that lung cancer mortality in both males and females has been elevated for quite some time. Furthermore, other cancer types (thought to be related to asbestos exposure) are also elevated, although not to the extent that lung cancer is. Because the lung cancer rates were considerably elevated and since the Iron Horse Park hazardous waste site may have been a source of asbestos exposure in the past, risk ratios, standardized by age and sex were calculated for 1975-1985 (population data for the 1969-1974 time

period was unavailable) to determine whether Billerica residents, 18 years of age and older living within a 1 mile radius of the site were at a greater risk of dying of lung cancer as compared to Billerica residents outside of a 1 mile radius of the site. That is, assuming that persons living within 1 mile of the site are "exposed" and persons living outside of a 1 mile radius are "unexposed". In several cases the risk ratio appeared elevated for individuals living within 1 mile of the site.

Based on these findings the MDPH will immediately begin work on the design and conduct of a Phase II epidemologic investigation, to be conducted concurrent with intervention activities established within the community with technical assistance from the MDPH. These activities will be aimed at the assessment and reduction of lifstyle risk factors.

I. INTRODUCTION

In the early spring of 1987 the Massachusetts Department of Public Health Division of Environmental Epidemiology and Toxicology (MDPH, DEET) and the Massachusetts Department of Environmental Quality Engineering Office of Research and Standards (DEQE,ORS) collaborated in developing a draft proposal to address health and environmental concerns voiced by a committee comprised of state and local government offices and concerned citizens of the town of Billerica, MA. As part of this proposal the MDPH Community Assessment Unit (CAU) was asked to review available cancer incidence data for Billerica. The results of these analyses were presented at a public meeting in Billerica in June, 1987. Because of the magnitude of environmental contamination and the long-standing general public health concerns voiced by the citizens group, the CAU agreed to review all available cancer mortality data (1969-1985) for the twelve major sites of cancer: Stomach, colon/rectum, liver, pancreas, lung, breast, cervix, other female reproductive organs, prostate, bladder, kidney and leukemia.

Environmental and health concerns were focused largely around the Iron Horse Park hazardous waste site in North Billerica. Iron Horse Park is one of the 21 hazardous waste sites in Massachusetts that has been placed on the National Priorities List (NPL) by the U.S. Environmental Protection Agency (US EPA). Iron Horse Park covers approximately 552 acres of land near the Tewksbury border in North Billerica. Past

industrial activities have resulted in considerable contamination of surface and ground water and soils. The contaminants of concern include asbestos, heavy metals, polycyclic aromatic hydrocarbons (PAH's) and volatile organic compounds (VOC's).

The following investigation is a descriptive assessment of cancer mortality in Billerica, MA for the seventeen year period 1969-1985. The purpose of reviewing and analyzing these data was to look at trends in cancer mortality over time for the town of Billerica. The results of these analyses will be considered in addressing the potential need for future environmental and public health initiatives for the town.

II. METHODS

Standardized Mortality Ratios (SMR) were calculated for the town as a whole and then for individual census tracts utilizing data supplied by the MDPH Division of Health Statistics and Research (DHSR). SMR's were calculated for the entire time period investigated (1969-1985) and for three time intervals (1969-1974, 1975-1980, and 1981-1985) to better assess cancer mortality trends over time.

The SMR is the ratio of the observed or actual number of cancer deaths to the expected number of cancer deaths standardized by age and sex. An SMR equal to 100 indicates that the number of deaths in an area is equal to what would have been expected based on Massachusetts cancer mortality rates. An SMR of greater than 100 indicates that more cancer deaths occurred than were expected and an SMR of less than 100 means that fewer deaths occurred than were expected.

Care must be taken when interpreting the SMR since one must take into account not only how large it is but also how stable it is. An SMR of 200 based on 3 expected deaths and 6 observed is large but may be due primarily to 1 or 2 excess deaths occurring from natural variation in mortality patterns. Alternatively, an SMR of 200 based on 300 expected deaths and 600 observed has the same magnitude as the previous SMR but it is very stable. It is quite unlikely that there would be 300 excess deaths occurring by chance alone.

A standard statistical (chi-square) test was used to determine the stability or statistical significance of the SMR where more than 5 deaths were observed. A significant difference between the actual number of

deaths and the expected number of deaths means that the occurrence is probably not due to chance. Two common cut-off points, referred to as "p-values", for statistical significance are probabilities of less than 0.05 ($p < 0.05$) and less than 0.01 ($p < 0.01$). This means that the probability that the difference between the observed and expected values was due to chance is less than 5 chances in 100 (where $p < 0.05$) or less than 1 chance in 100 (where $p < 0.01$).

Place of residence at the time of death was examined for each decedent to determine if there was any geographic clustering of deaths. Plotting of the residence at time of death was somewhat complicated because certain streets cross over census tract borders and/or are quite long. There are also several street names that occur more than once in different areas of the town (e.g.: Chestnut, Brown, Arch, Walnut, etc.). In addition, the town had been redistricted twice during the time period under investigation. In order to plot cases as accurately as possible, it was necessary for a research analyst to make a site visit to Billerica to locate the precise position of several addresses and to access town records at the town hall.

III. RESULTS

Cancer mortality for all 17 years (1969-1985) reviewed are presented by cancer site for the town as a whole and for each individual census tract in table 1 and maps 1-12. Cancer mortality for each site is also presented for the three time periods investigated for the town as a whole and each census tract separately in tables 2-13. These time trends are graphically depicted in figures 1-12 and maps 1,1A, 1B, 1C - 12, 12A, 12B, 12C. Lung cancer mortality is presented with additional figures (5A-E) to assess lung cancer mortality in each census tract. Maps 1A - 12C are presented in the text as "map series". A "map series" is the series of maps that shows the residence of each decedent. They are organized by total 17 year mortality and then by time interval; i.e.: Map series 1 indicates map 1 (mortality for 1969-1985), map 1a (mortality for 1969-1974), map 1b (mortality for 1975-1980) and map 1c (mortality for 1981-1985).

The interpretation of these data and the major risk factors associated with morbidity and mortality due to each type of cancer will be discussed in detail later in this report.

Stomach Cancer:

Mortality due to cancer of the stomach for both sexes combined occurred at the rate expected for the 17 years reviewed (1969-1985). Twenty-six deaths were observed while 25.7 were expected (SMR = 101) based on the statewide stomach cancer mortality experience. Female stomach

Table 1

Cancer Mortality in Billerica 1969-1985

Cancer Type	TOWN	3161	3162	3163	3164	3165
STOMACH						
Males:	12/15.9= 75	4/3.9=103	3/3.9= 77	0/2.3=0	2/2.1= 95	3/3.8= 79
Females:	14/ 9.8=143	3/2.9=103	3/2.0=150	4/1.4=286	0/1.0=0	4/2.7=148
Total:	26/25.7=101	7/6.8=103	6/5.9=102	4/3.7=108	2/3.1= 65	7/6.5=108
COLORECTAL						
Males:	43/43.9= 98	6/10.6= 57	9/10.7= 84	6/ 6.6= 91	10/5.6=179	12/10.7=112
Females:	41/41.5= 99	9/12.2= 74	10/ 8.3=120	6/ 5.6=107	5/4.2=119	11/11.2= 98
Total:	84/85.4= 98	15/22.8= 66	19/19.0=100	12/12.2= 98	15/9.8=153	23/21.9=105
LIVER						
Males:	3/ 3.0=100	0/0.8= 0	0/ 0.6= 0	1/ 0.5=200	1/0.3=333	1/ 0.6=167
Females:	3/ 1.1=273	3/0.3=999	0/ 0.2= 0	0/ 0.2= 0	0/0.5= 0	0/ 1.0= 0
Total:	6/ 4.1=146	3/1.1=273	0/ 0.8= 0	1/ 0.7=143	1/0.8=125	1/ 1.6= 63
PANCREAS						
Males:	18/16.4=110	5/ 4.1=122	5/ 4.0=125	1/ 2.4= 42	4/ 2.1=190	3/ 3.9= 77
Females:	12/13.1= 92	5/ 4.0=125	3/ 2.7=111	1/ 1.9= 53	1/ 1.4= 71	2/ 3.7= 54
Total:	30/29.5=102	10/ 8.1=123	8/ 6.7=119	2/ 4.3= 47	5/ 3.5=143	5/ 7.6= 66
LUNG						
Males:	142/102.1=139++	38/25.1=151+	38/24.4=156++	18/15.6=115	13/13.6= 96	36/23.6=153+
Females:	47/ 36.6=128	8/10.4= 77	15/ 7.9=190+	8/ 5.6=143	6/ 4.2=143	10/ 8.8=114
Total:	189/138.7=136++	46/35.5=130	53/32.3=164++	26/21.2=123	19/17.8=107	46/32.4=142+
BREAST						
Females:	44/62.5= 70 -	10/18.0= 56	6/13.3= 45	11/ 8.8=125	6/ 7.4= 81	11/13.3= 83
CERVIX						
Females:	8/ 7.5=107	2/ 2.1= 95	3/ 1.6=188	1/ 1.2= 83	1/ 1.0=100	1/ 1.8= 56

All values rounded and presented as Observed/Expected x 100=SMR
+ or - indicates statistical significance at 0.05 level
++ or -- indicates statistical significance at 0.01 level

Statistical significance not calculated when number of deaths < 5

table 1 continued.

Cancer Type	TOWN	3161	3162	3163	3164	3165
OTHER FEMALE						
Females:	19/25.0= 76	5/ 7.3= 68	5/ 5.3= 94	3/ 3.5= 86	5/ 2.9=172	3/ 6.2= 48
PROSTATE:						
Males:	19/27.4= 69	6/ 6.4= 94	2/ 5.5= 36	4/ 4.1= 98	3/ 3.1= 97	4/ 7.2= 56
BLADDER:						
Males:	15/ 9.9=152	1/ 2.5= 40	3/ 2.4=125	3/ 1.4=214	1/ 1.2= 83	7/ 2.5=280+
Females:	4/ 4.6= 87	1/ 1.4= 71	2/ 0.9=222	1/ 0.5=200	1/ 0.4=250	1/ 1.2= 83
Total:	19/14.5=131	2/ 3.9= 51	5/ 3.3=152	4/ 1.9=211	2/ 1.6=125	8/ 3.7=216+
KIDNEY:						
Males:	8/ 7.9=101	3/ 1.9=158	1/ 1.9= 53	1/ 1.2= 83	1/ 1.1= 91	2/ 1.7=118
Females:	9/ 4.6=196+	4/ 1.5=267	3/ 1.1=273	1/ 0.7=143	0/ 0.7= 0	1/ 1.2= 83
Total:	17/12.5=136	7/ 3.4=206	4/ 3.0=133	2/ 1.9=105	1/ 1.8= 56	3/ 2.9= 103
LEUKEMIA:						
Males:	15/14.9=101	5/ 4.0=125	1/ 3.4= 29	3/ 2.2=136	2/ 2.2= 91	4/ 3.3=121
Females:	16/11.2=143	5/ 3.3=152	3/ 2.3=130	4/ 1.5=267	3/ 1.4=214	1/ 2.6= 38
Total:	31/26.1=119	10/ 7.3=137	4/ 5.7= 70	7/ 3.7=189	5/ 3.6=139	5/ 5.9= 85

All values rounded and presented as Observed/Expected x 100 = SMR
+ or - indicates statistical significance at 0.05 level
++ or -- indicates statistical significance at 0.01 level
Statistical significance not calculated when number of deaths < 5

Table 2

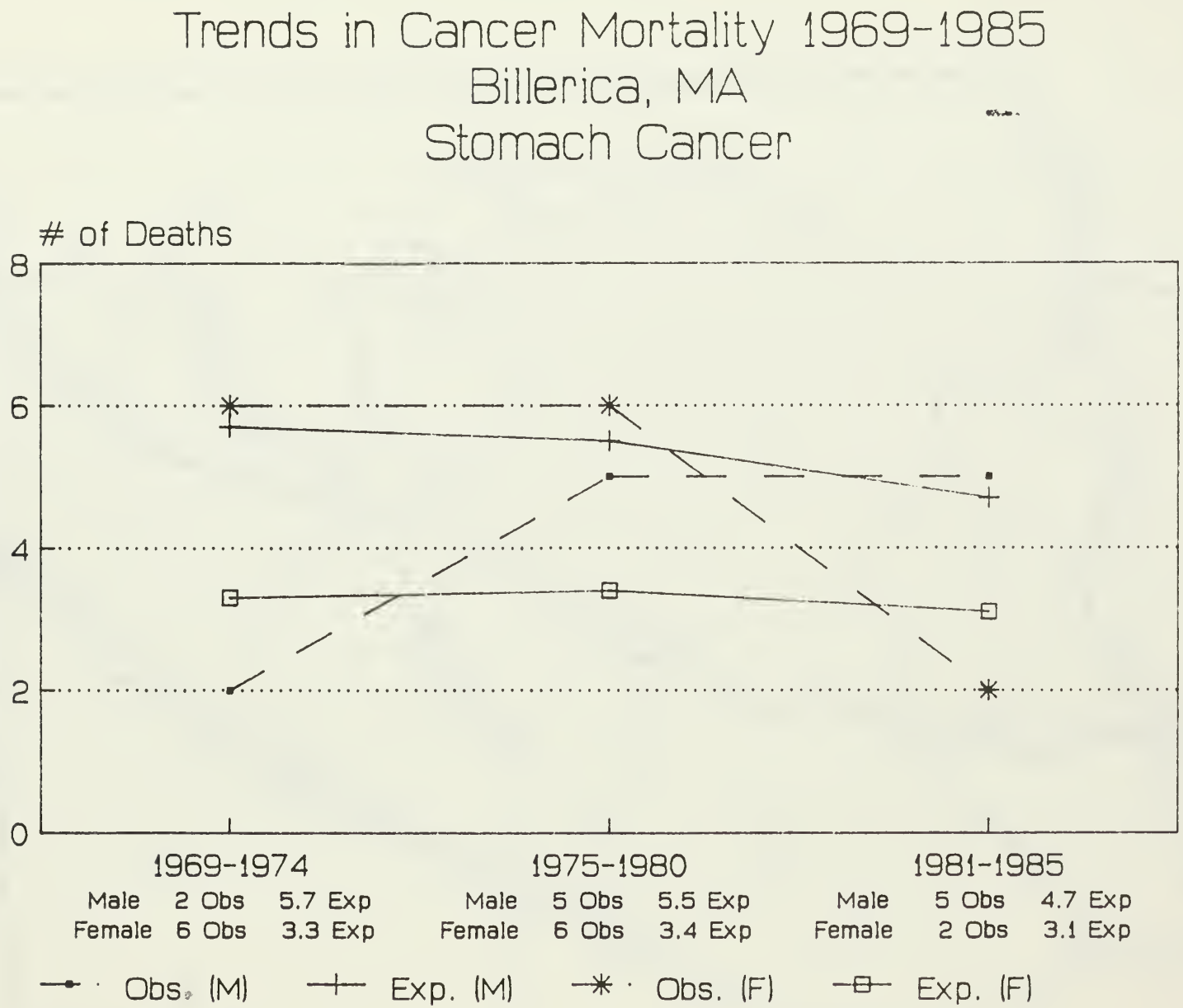
Standardized Mortality Ratios
Stomach Cancer
Billerica, MA

	1969-1974		1975-1980		1981-1985	
	Male	Female	Male	Female	Male	Female
TOWN	2/5.7= 35	6/3.3=180	5/5.5= 91	6/3.4=175	5/4.7=107	2/3.1= 65
3161	1/1.3= 75	2/1.0=201	2/1.4=148	1/1.0= 98	1/1.2= 85	0/0.9=0
3162	0/1.5=0	0/0.7=0	1/1.3= 76	1/0.7=150	2/1.1=189	2/0.6=355
3163	0/0.7=0	3/0.4=822	0/0.8=0	1/0.5=213	0/0.8=0	0/0.5=0
3164	1/0.8=131	0/0.4=0	1/0.7=135	0/0.3=0	0/0.6=0	0/0.3=0
3165	0/1.4=0	1/0.9=113	1/1.3=77	3/0.9=322	2/1.1=183	0/0.9=0

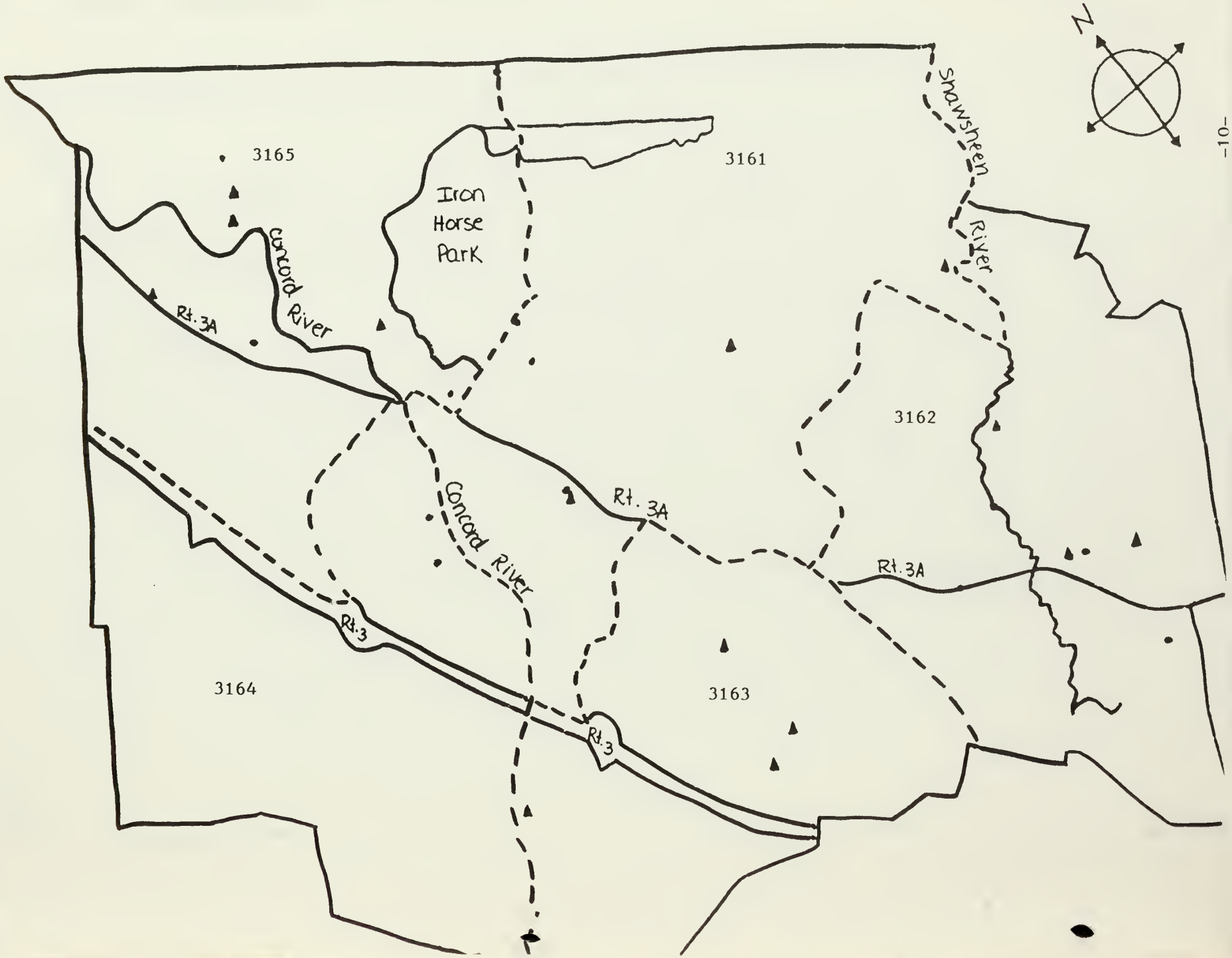
Note: All values rounded and presented as Observed number/Expected number x 100= Standardized Mortality Ratio

+ or - indicates statistical significance at the 0.05 level
++ or -- indicates statistical significance at the 0.01 level
Statistical significance not calculated when number of deaths < 5

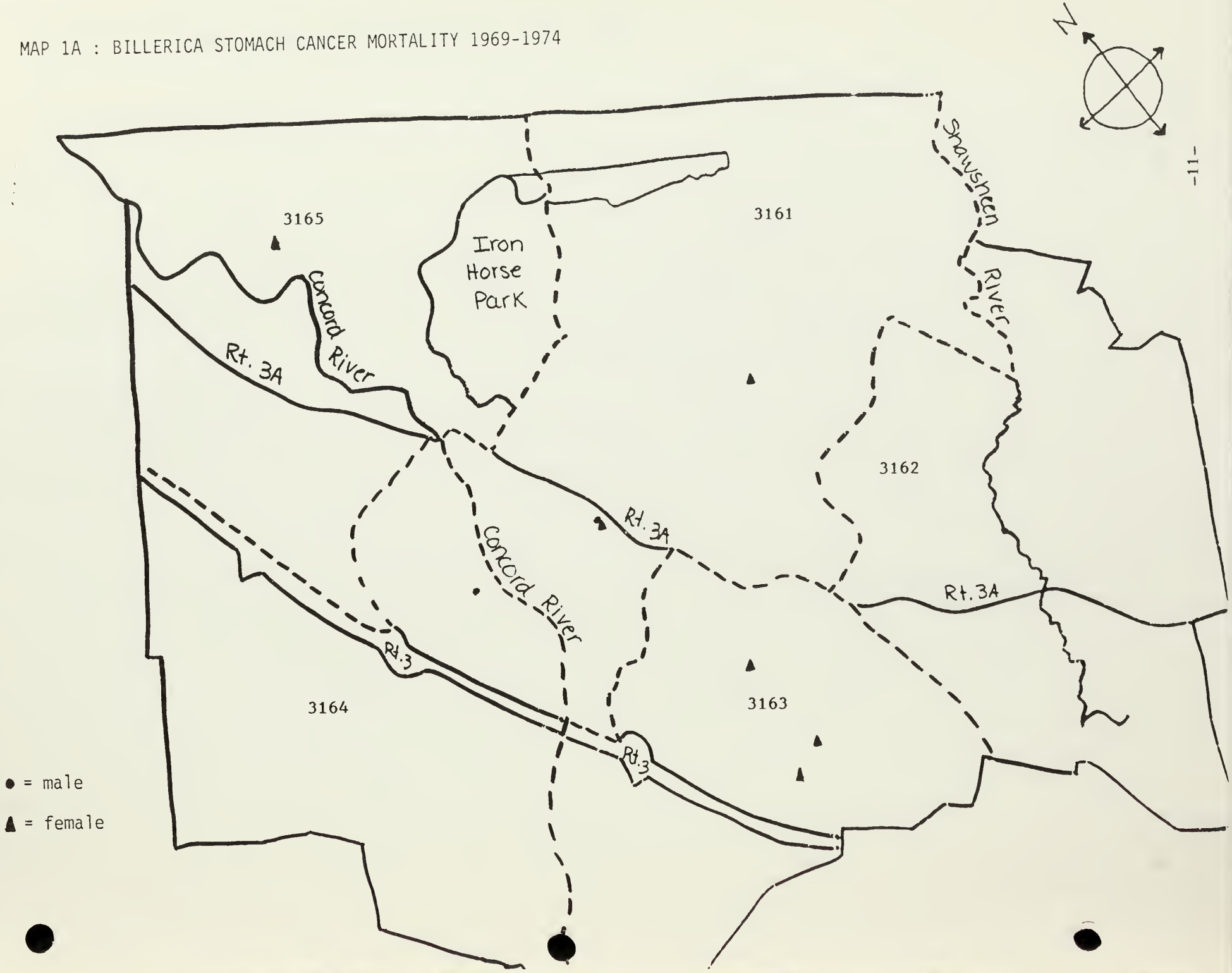
Figure 1


Trends in Cancer Mortality 1969-1985
Billerica, MA
Stomach Cancer
# of Deaths
8
6
4
2
0
1969-1974
Male 2 Obs 5.7 Exp
Female 6 Obs 3.3 Exp
1975-1980
Male 5 Obs 5.5 Exp
Female 6 Obs 3.4 Exp
1981-1985
Male 5 Obs 4.7 Exp
Female 2 Obs 3.1 Exp
Obs. (M)
Exp. (M)
Obs. (F)
Exp. (F)

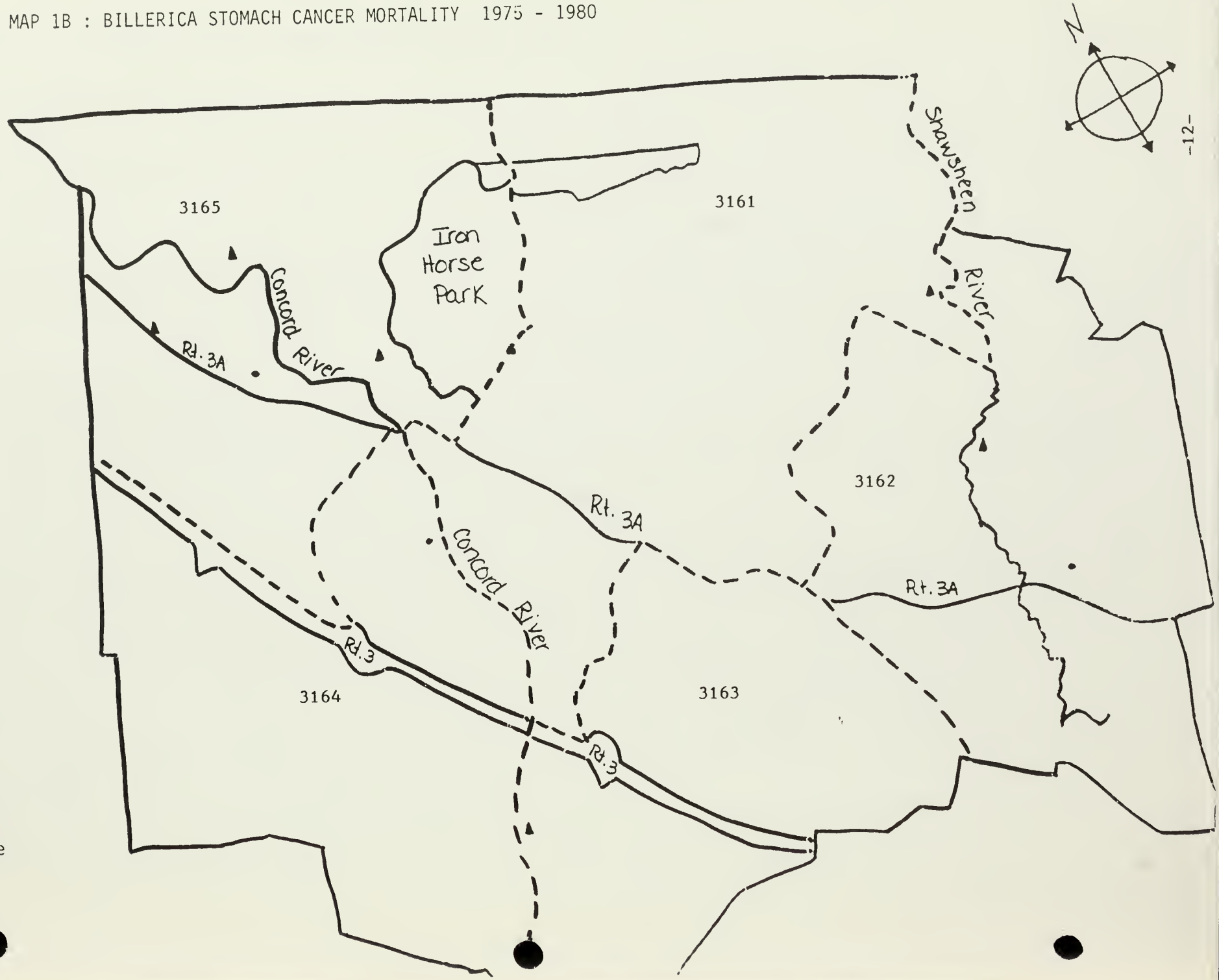
MAP 1: BILLERICA STOMACH CANCER MORTALITY 1969-1985



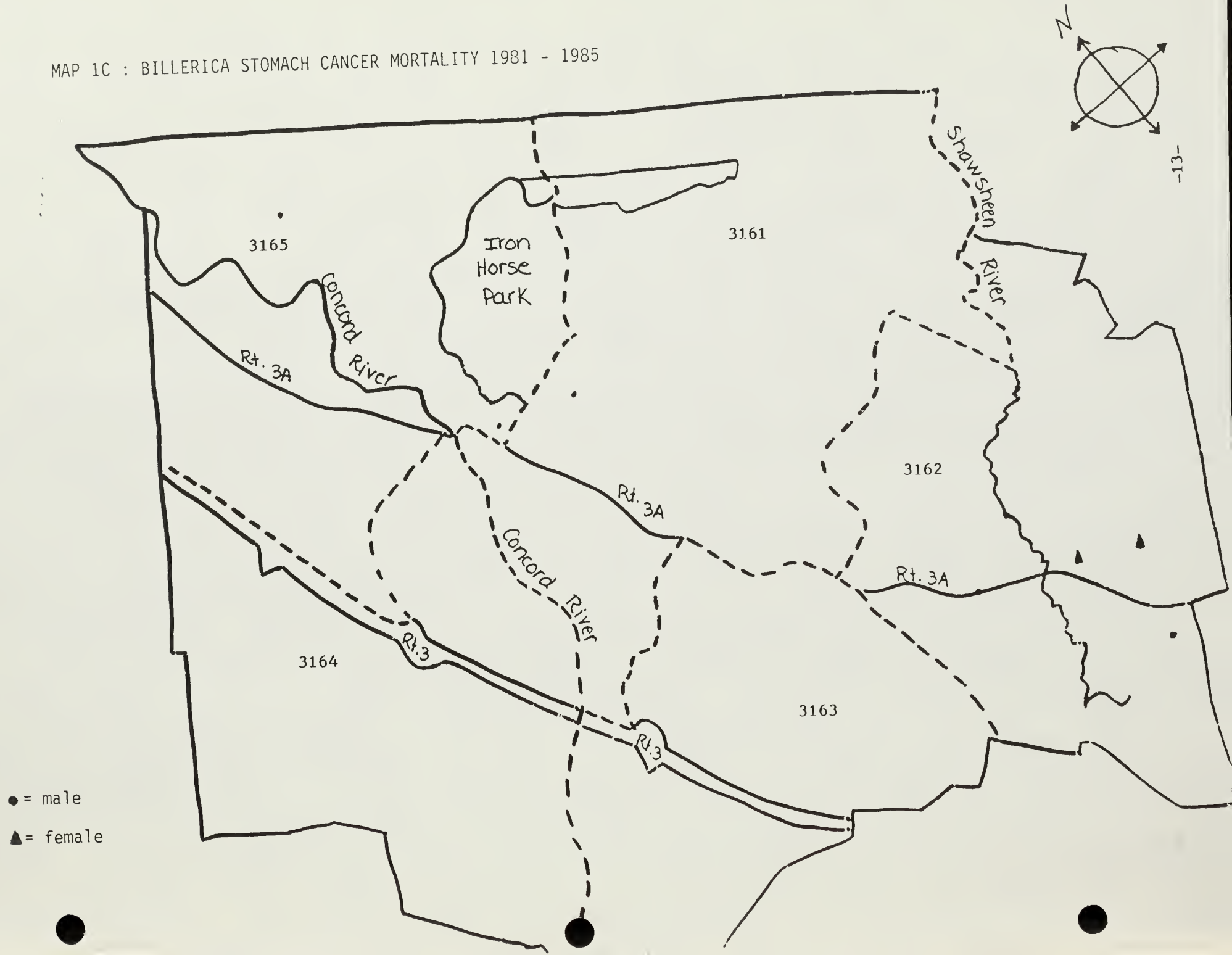
MAP 1A : BILLERICA STOMACH CANCER MORTALITY 1969-1974



MAP 1B : BILLERICA STOMACH CANCER MORTALITY 1975 - 1980



MAP 1C : BILLERICA STOMACH CANCER MORTALITY 1981 - 1985



cancer mortality was somewhat elevated (14 observed, 9.8 expected; SMR = 143) and males mortality due to cancer of the stomach occurred less often than expected (12 observed, 15.9 expected; SMR = 75). This pattern is essentially repeated throughout each census tract when considering the entire 17 year period (table 1).

When considering the 3 time intervals separately, males experienced fewer stomach cancer deaths than expected townwide during 1969-1974 (2 observed, 5.7 expected; SMR = 35). Stomach cancer mortality was practically what would have been expected during 1975-1980 (5 observed, 5.1 expected; SMR = 91) and 1981-1985 (5 observed, 4.7 expected; SMR = 107). Townwide, female stomach cancer mortality was elevated during 1969-1974 (6 observed, 3.3 expected; SMR = 180) and during 1975-1980 (6 observed, 3.4 expected SMR = 175). Fewer female deaths than expected occurred during 1981-1985 (2 observed, 3.1 expected; SMR = 65). Most of the elevations within particular census tracts for each time period are based on very small numbers of deaths. Exceptions are in female mortality in census tract 3163 during 1969-1974, census tract 3165 during 1975-1980 and census tract 3162 during 1981-1985. In general, however, deaths were evenly distributed both in terms of time and geographic distribution. (table 2, figure 1, and map series 1).

Colon/Rectum:

Deaths due to cancers of the colon and rectum are presented in table 3 and figure 2 and map series 2. Overall the number of deaths due to these types of cancer was slightly less than would be expected (84 observed, 85.4 expected; SMR = 98). Considered separately, both male and

Table 3

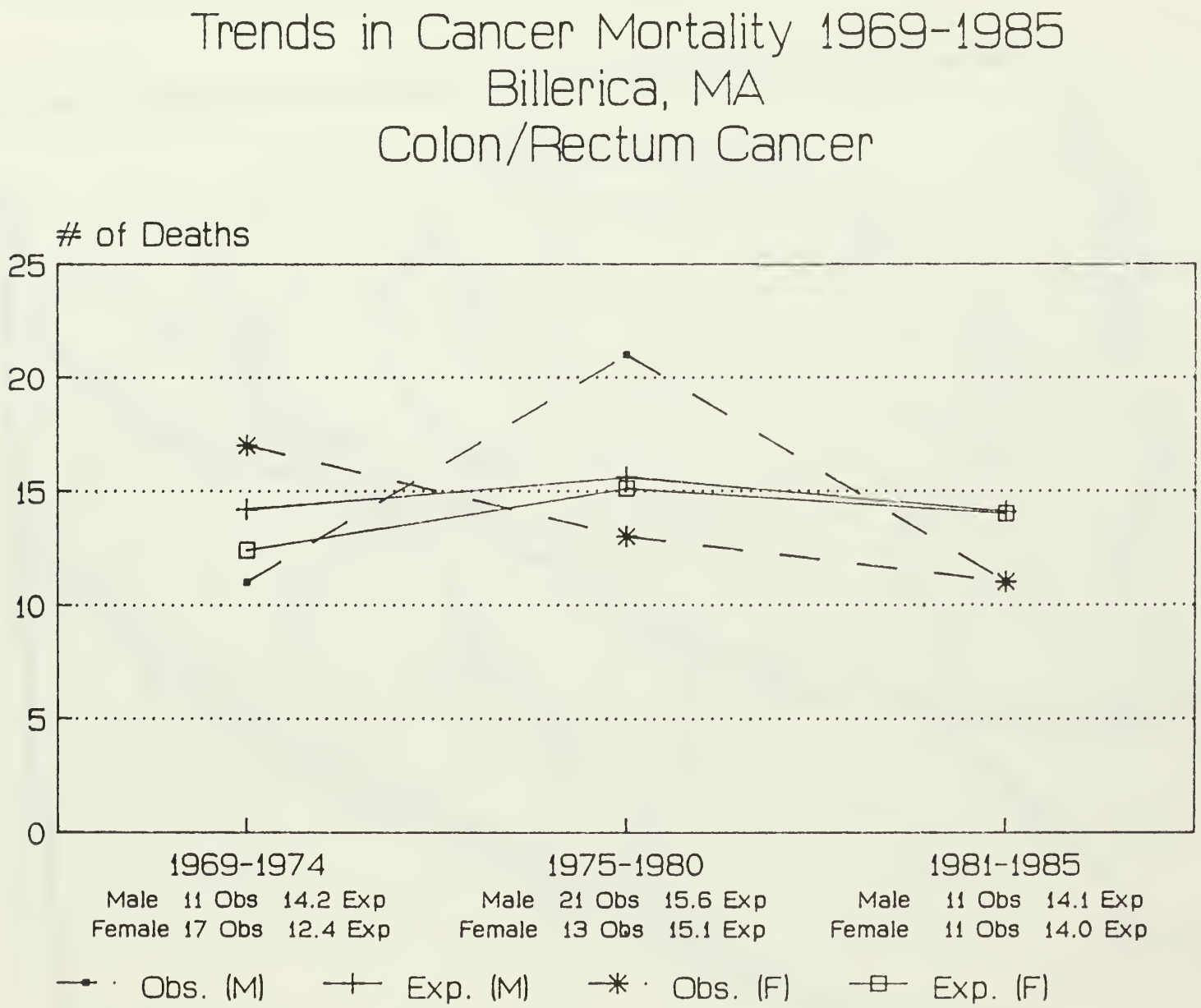
Standardized Mortality Ratios
Colorectal Cancers
Billerica, MA

	1969-1974		1975-1980		1981-1985	
	Male	Female	Male	Female	Male	Female
TOWN	11/14.2=78	17/12.4=138	21/15.6=134	13/15.1=86	11/14.1=78	11/14.0=79
3161	3/ 3.3=90	5/ 3.6=139	2/ 3.8=53	1/ 4.5=22	1/ 3.5=29	3/ 4.1=73
3162	2/ 3.7=54	4/ 2.7=148	6/ 3.8=159	4/ 3.0=134	1/ 3.2=31	2/ 2.6=78
3163	1/ 1.8=54	3/ 1.4=218	4/ 2.4=168	3/ 2.1=144	1/ 2.4=41	0/ 2.1=0
3164	1/ 1.9=52	3/ 1.4=211	4/ 2.1=193	0/ 1.5=0	5/ 1.6=304+	2/ 1.3=160
3165	4/ 3.5=116	2/ 3.2=61	5/ 3.8=133	5/ 4.1=122	3/ 3.4=89	4/ 3.9=103

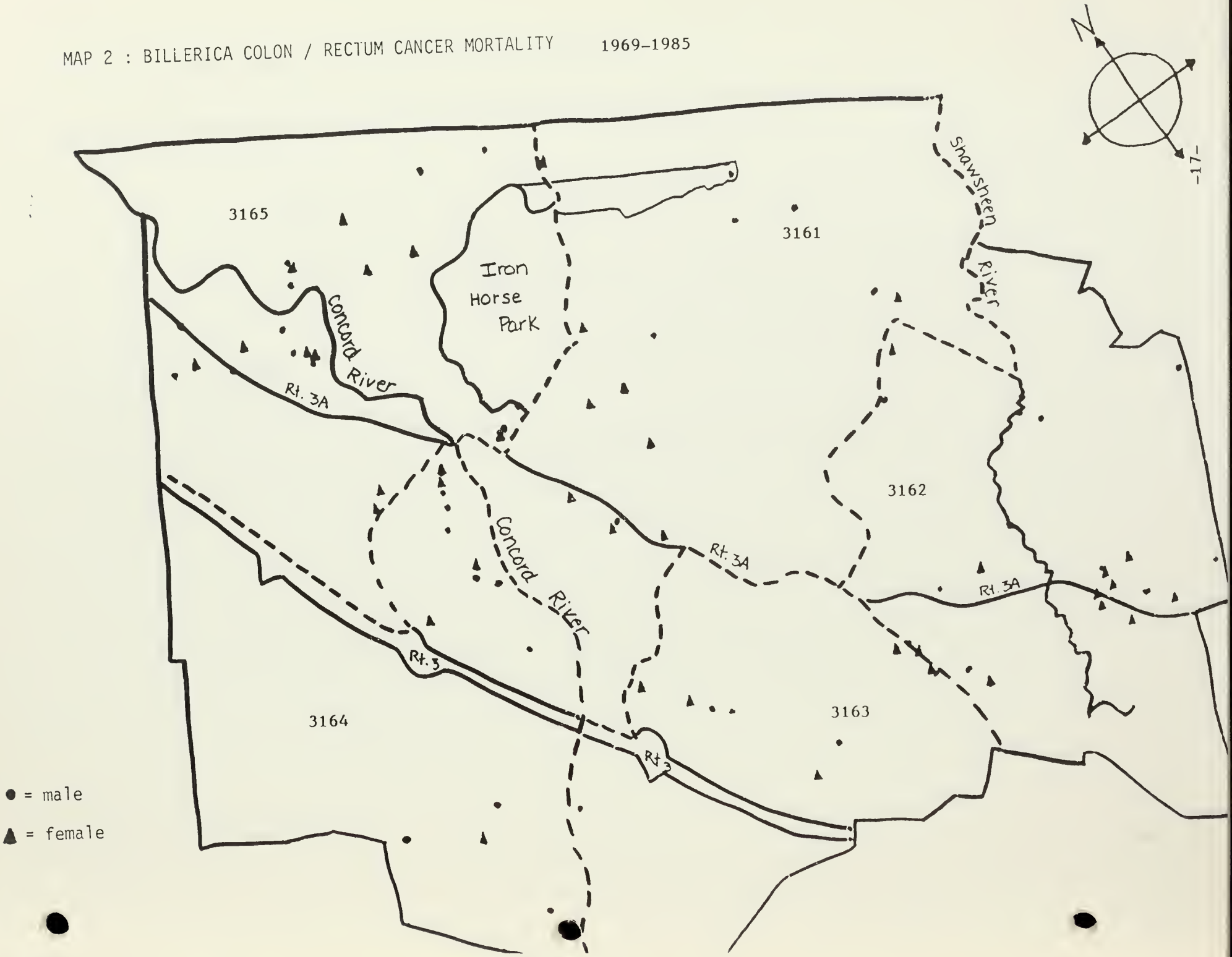
Note: All values rounded and presented as Observed number/Expected number x 100= Standardized Mortality Ratio

+ or - indicates statistical significance at the 0.05 level
++ or -- indicates statistical significance at the 0.01 level
Statistical significance not calculated when number of deaths < 5

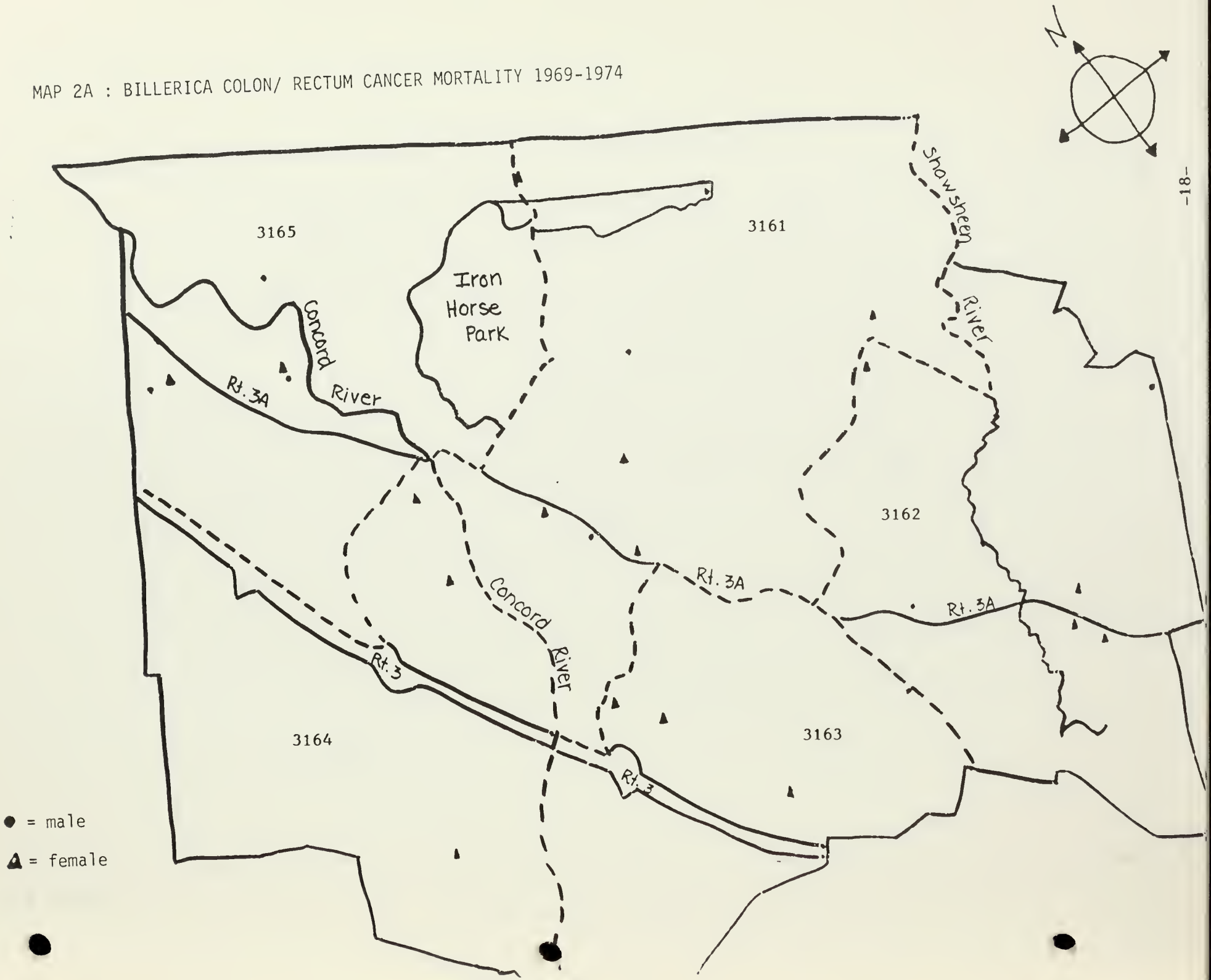
Figure 2


Trends in Cancer Mortality 1969-1985
Billerica, MA
Colon/Rectum Cancer
# of Deaths
25
20
15
10
5
0
1969-1974
Male 11 Obs 14.2 Exp
Female 17 Obs 12.4 Exp
1975-1980
Male 21 Obs 15.6 Exp
Female 13 Obs 15.1 Exp
1981-1985
Male 11 Obs 14.1 Exp
Female 11 Obs 14.0 Exp
Obs. (M)
Exp. (M)
Obs. (F)
Exp. (F)

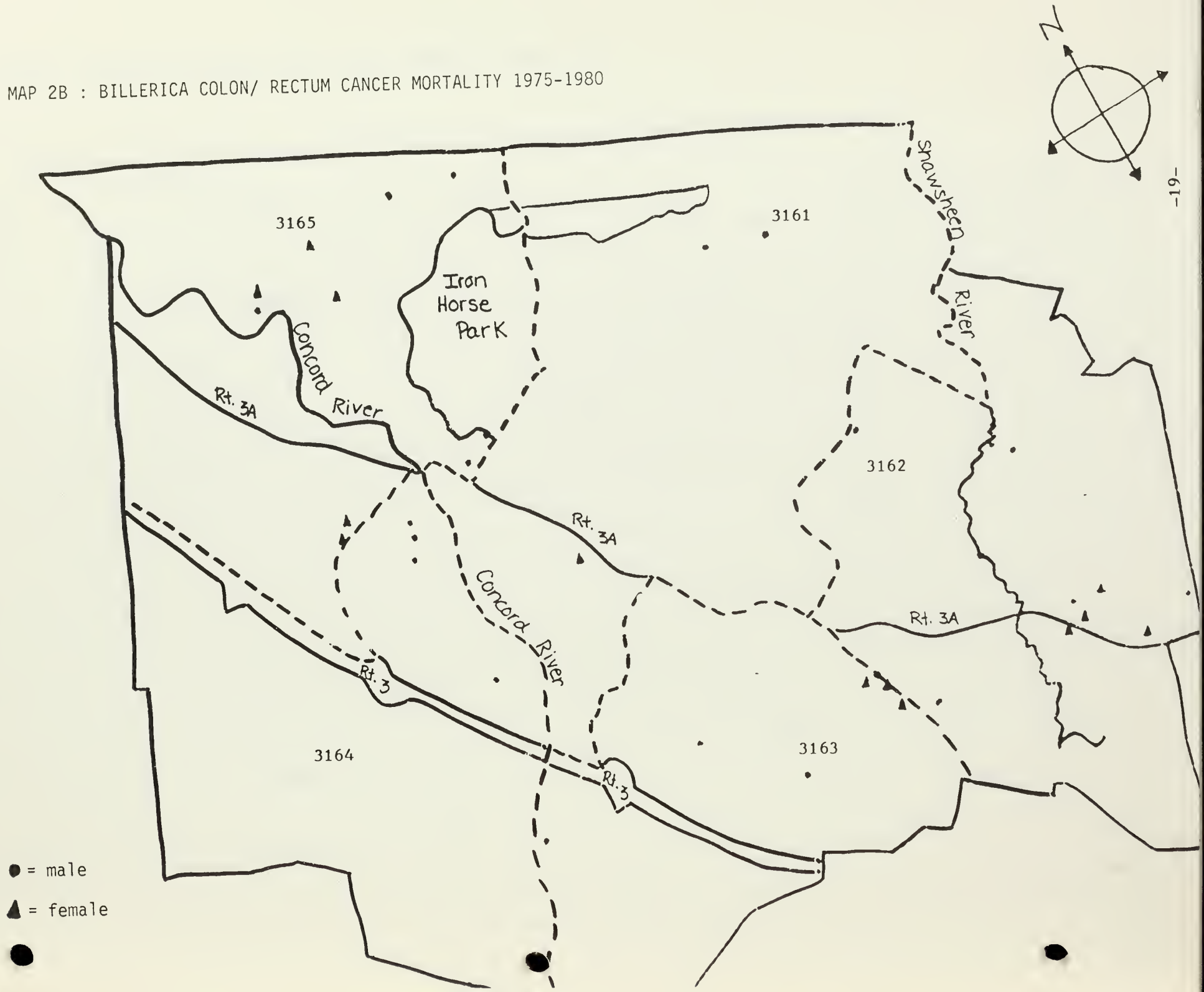
MAP 2 : BILLERICA COLON / RECTUM CANCER MORTALITY 1969-1985



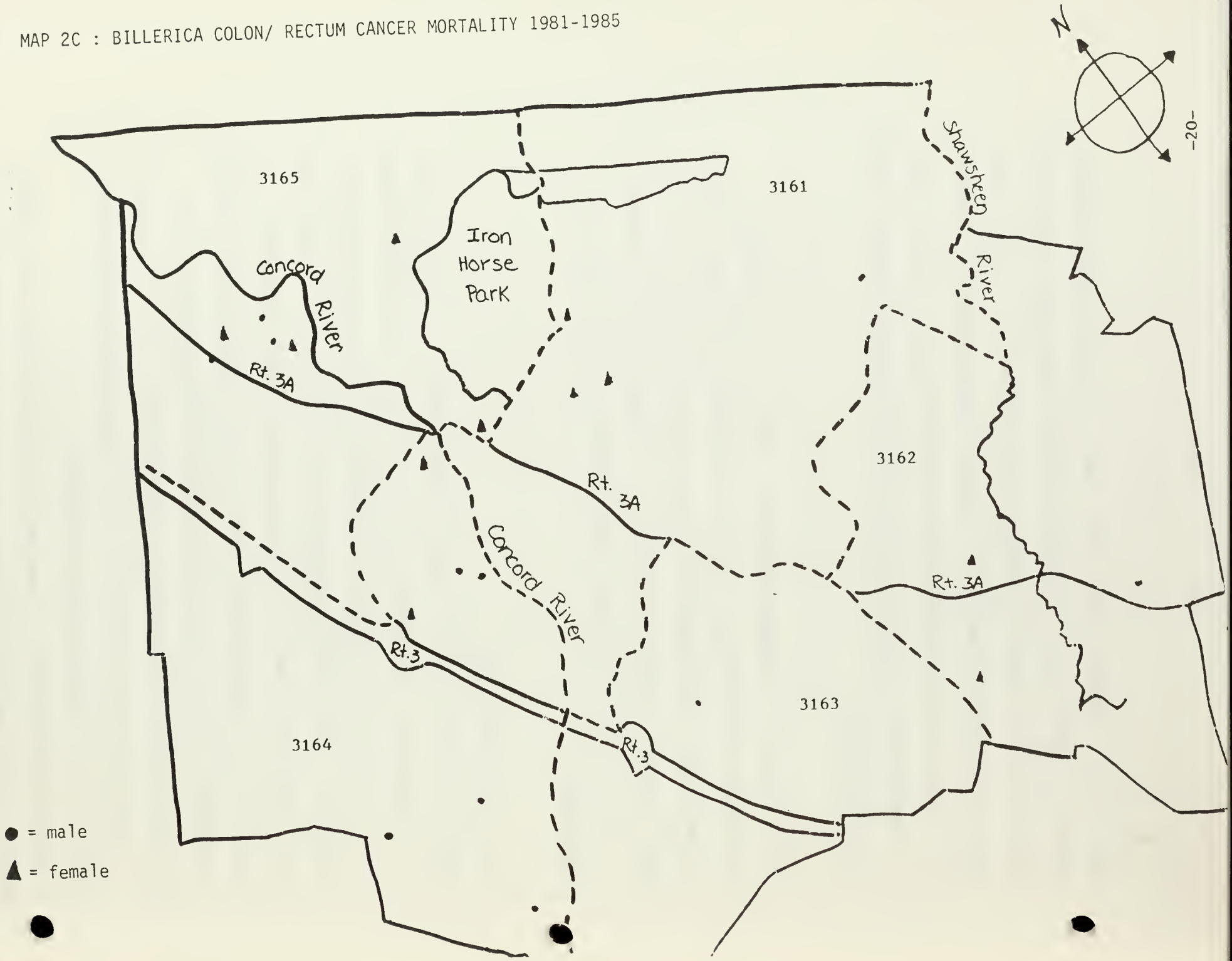
MAP 2A : BILLERICA COLON/ RECTUM CANCER MORTALITY 1969-1974



MAP 2B : BILLERICA COLON/ RECTUM CANCER MORTALITY 1975-1980



MAP 2C : BILLERICA COLON/ RECTUM CANCER MORTALITY 1981-1985



female colorectal mortality occurred slightly less than expected for the entire time period (males: 43 observed, 43.9 expected; SMR = 98 females: 41 observed, 41.5 expected; SMR = 99; table 1).

For 1969-1974 and 1975-1980 male and female mortality rates for the town were practically the inverse of one and other (i.e.: if male rates were elevated, females experienced fewer than expected deaths). This pattern was also consistent throughout the census tracts for the 1969-1974 period. Mortality rates for the most recent time period (1981-1985) have returned to a rate lower than expected in all census tracts but 3164 and male colorectal cancer mortality is statistically significantly elevated here (5 observed, 1.6 expected; SMR =304 $p < 0.05$). With regard to this elevation the deaths do not appear to be concentrating in any particular area of the census tract.

Liver Cancer:

Liver cancer mortality was slightly elevated for the total time period 1969-1985 (6 deaths observed, 4.1 expected; table 1); however, none of these events were concentrated in any one particular area of town nor were cases more prevalent in any one of the three time periods. Liver cancer mortality is presented in table 4, figure 3 and map series 3.

Pancreatic Cancer:

Deaths due to cancer of the pancreas are presented in table 5, figure 4 and map series 4. Considering the total study period, (table 1) these data do not show an elevation in pancreatic cancer mortality for the town of Billerica as a whole (30 observed, 29.5 expected; SMR = 102). Male pancreatic cancer mortality accounts for this slight overall elevation (18 observed, 16.4 expected; SMR = 110). Female pancreatic cancer mortality

Table 4

Standardized Mortality Ratios
Liver Cancer
Billerica, MA

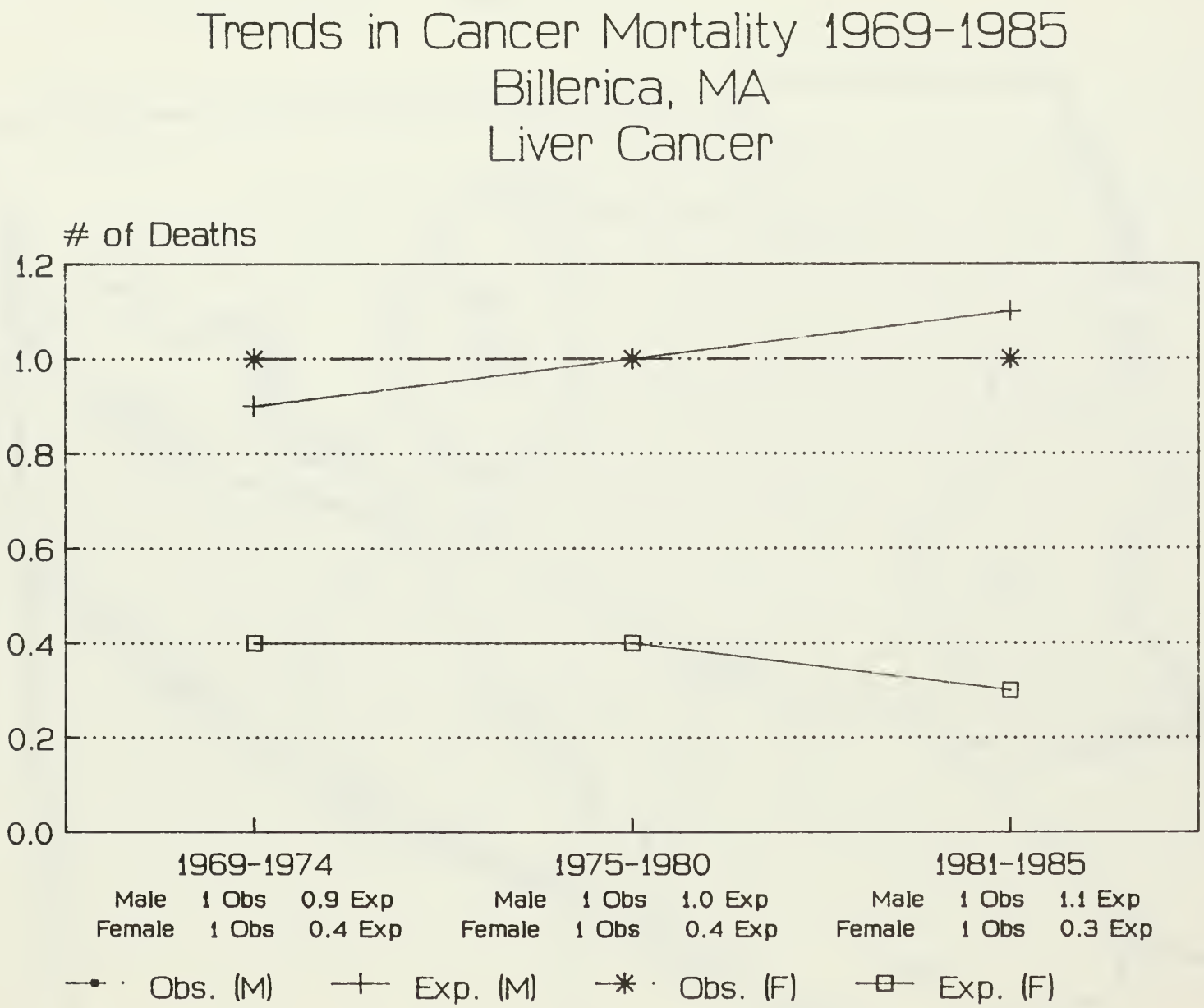
	1969-1974		1975-1980		1981-1985	
	Male	Female	Male	Female	Male	Female
Town	1/0.9=116	1/0.4=257	1/1.0=101	1/0.4=249	1/1.1=91	1/0.3=306
3161	0/0.2=0	1/0.1=895	0/0.3=0	1/0.1=846	0/0.3=0	1/0.1=999
3162	0/0.1=0	0/0.09=0	0/0.2=0	0/0.08=0	0/0.3=0	0/0.06=0
3163	0/0.1=0	0/0.05=0	0/0.2=0	0/0.06=0	1/0.2=526	0/0.05=0
3164	1/0.1=829	0/0.05=0	0/0.1=0	0/0.05=0	0/0.1=0	0/0.4=0
3165	0/0.2=0	0/0.06=0	1/0.2=453	0/0.1=0	0/0.2=0	0/0.8=0

Note: All values rounded and presented as Observed number/Expected number x 100 = Standardized Mortality Ratio

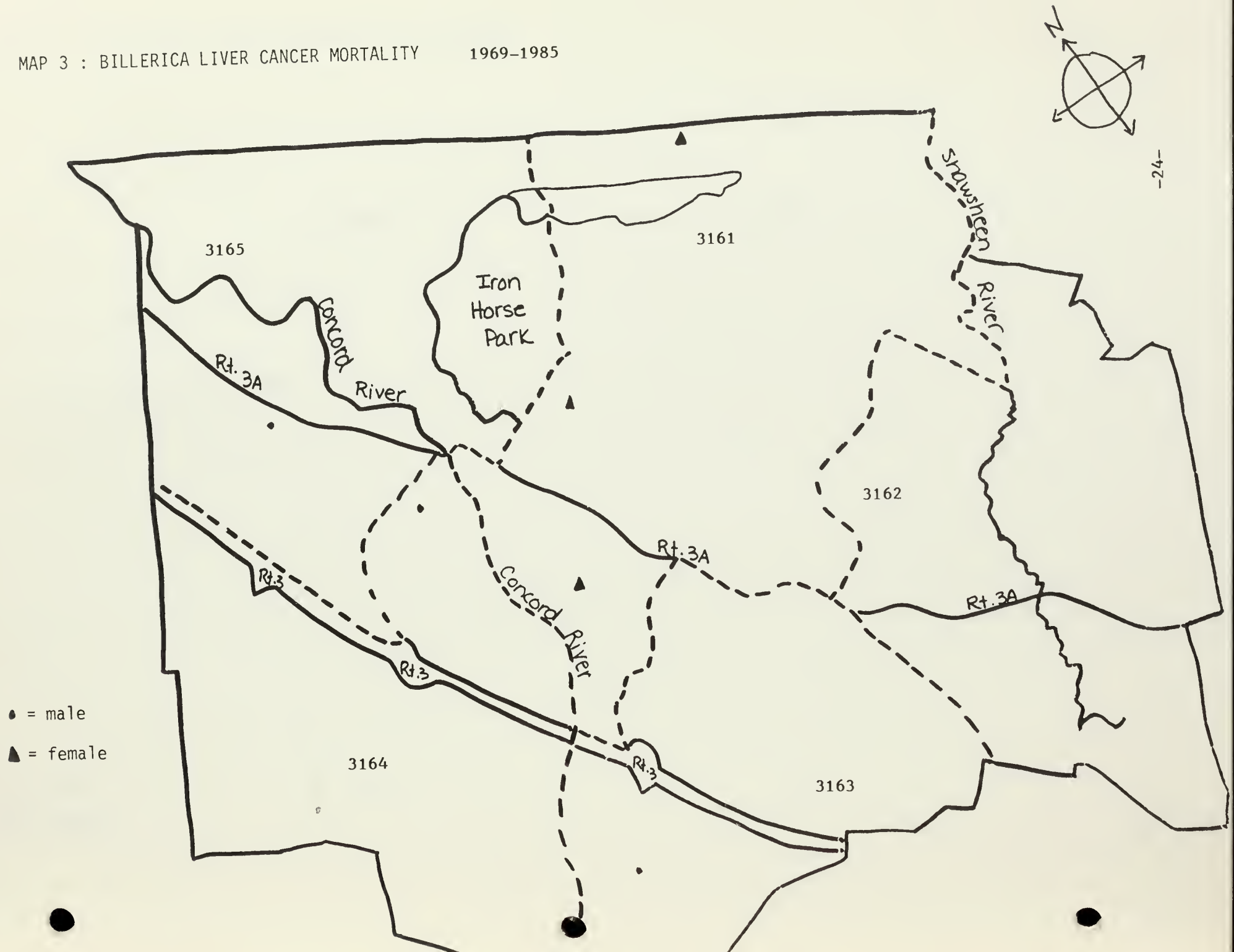
+ or - indicates statistical significance at the 0.05 level
++ or - - indicates statistical significance at the 0.01 level

Statistical significance not calculated where number of deaths is < 5.

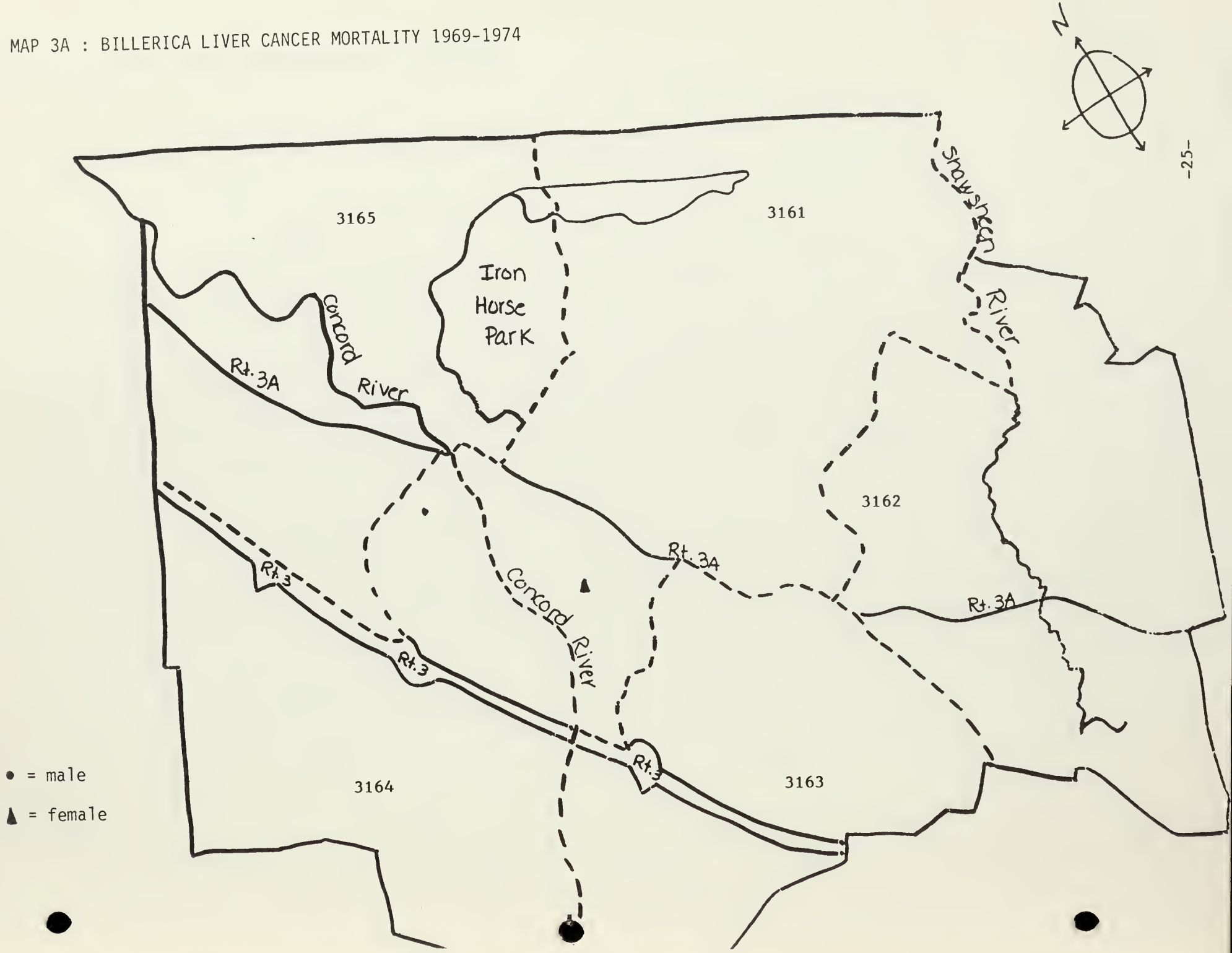
Figure 3


Trends in Cancer Mortality 1969-1985
Billerica, MA
Liver Cancer
# of Deaths
1.2
1.0
0.8
0.6
0.4
0.2
0.0
1969-1974
Male 1 Obs 0.9 Exp
Female 1 Obs 0.4 Exp
1975-1980
Male 1 Obs 1.0 Exp
Female 1 Obs 0.4 Exp
1981-1985
Male 1 Obs 1.1 Exp
Female 1 Obs 0.3 Exp
Obs. (M)
Exp. (M)
Obs. (F)
Exp. (F)

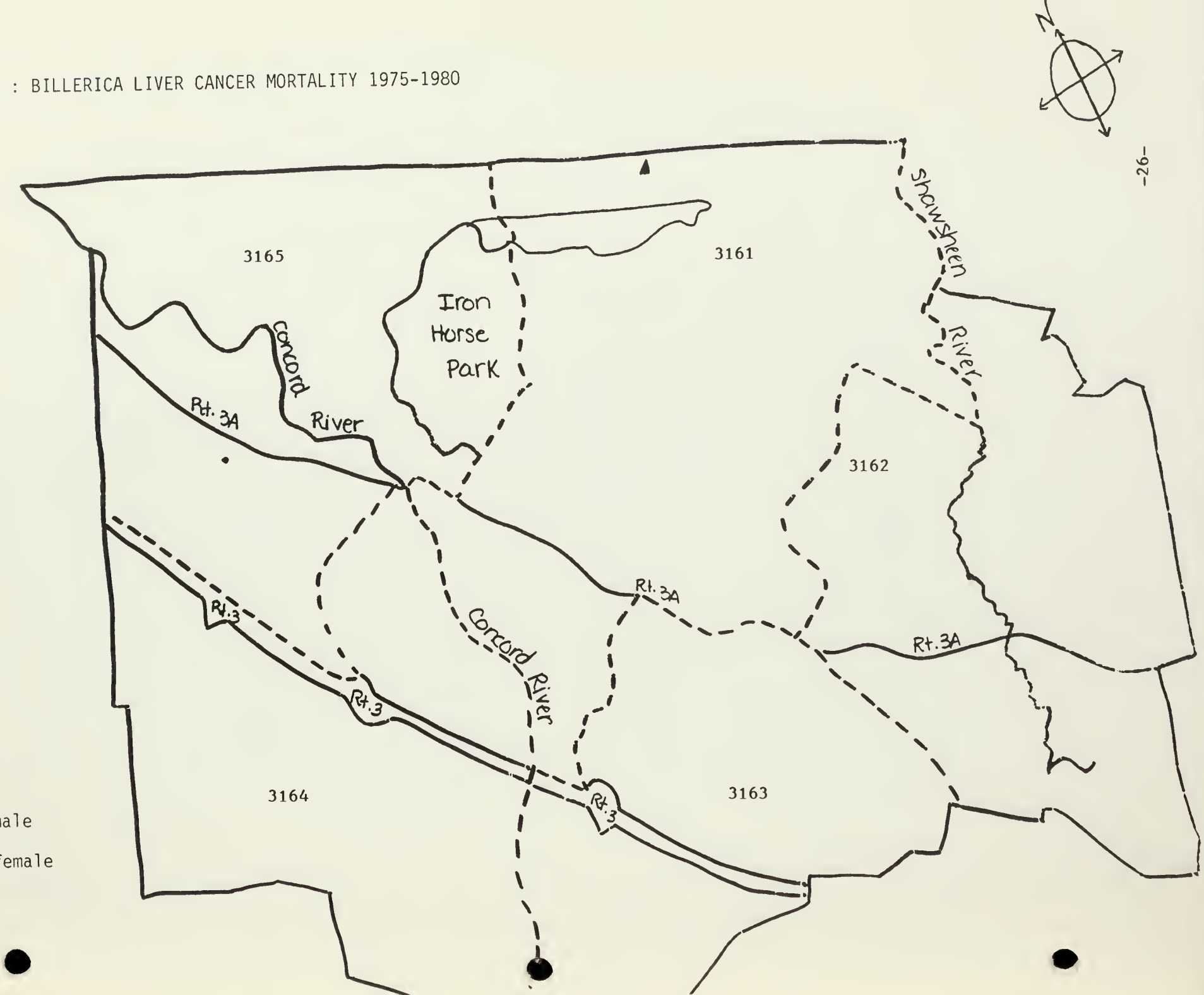
MAP 3 : BILLERICA LIVER CANCER MORTALITY 1969-1985



MAP 3A : BILLERICA LIVER CANCER MORTALITY 1969-1974



MAP 3B : BILLERICA LIVER CANCER MORTALITY 1975-1980



MAP 3C : BILLERICA LIVER CANCER MORTALITY 1981-1985

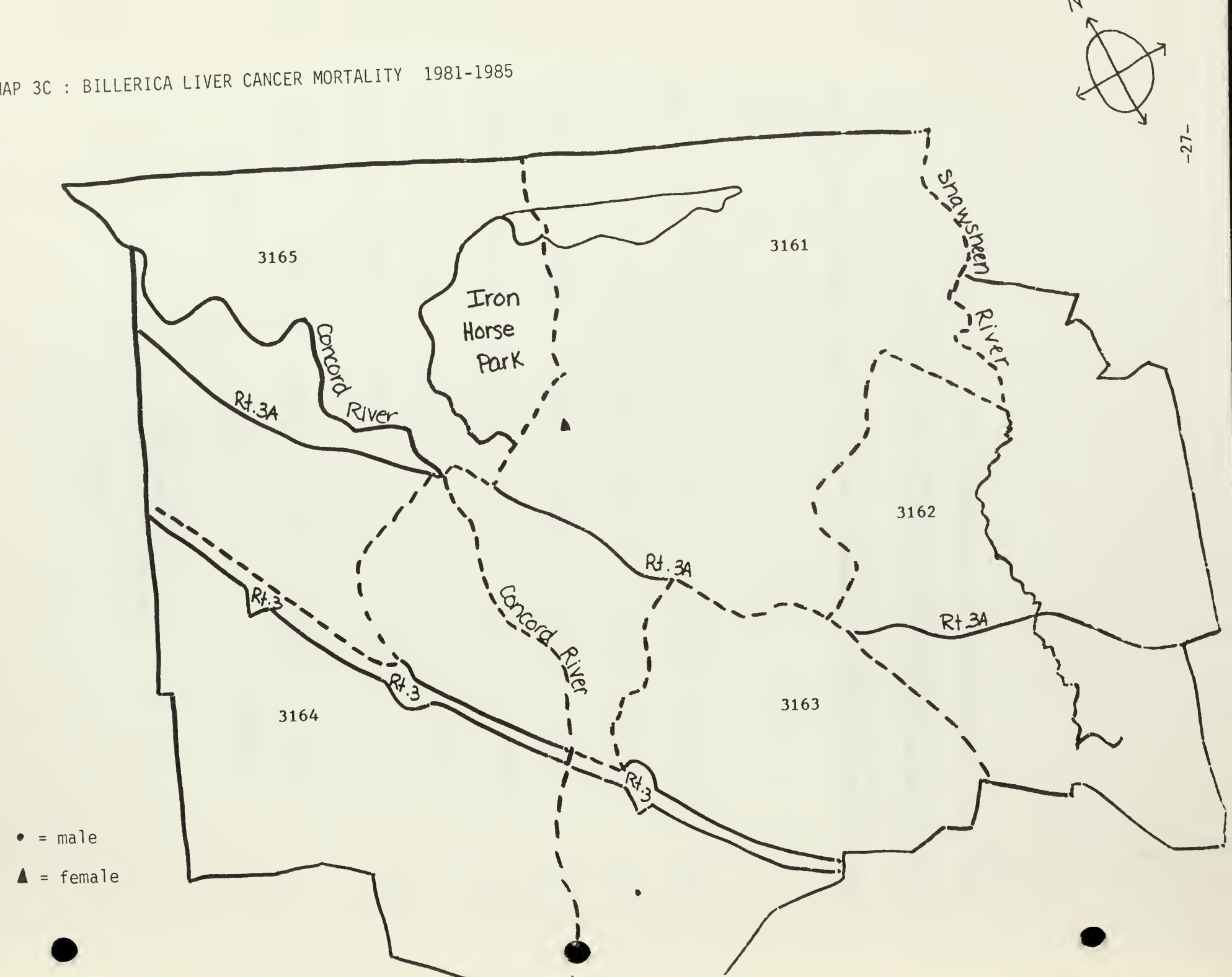


Table 5

Standardized Mortality Ratios
Pancreas Cancer
Billerica, MA

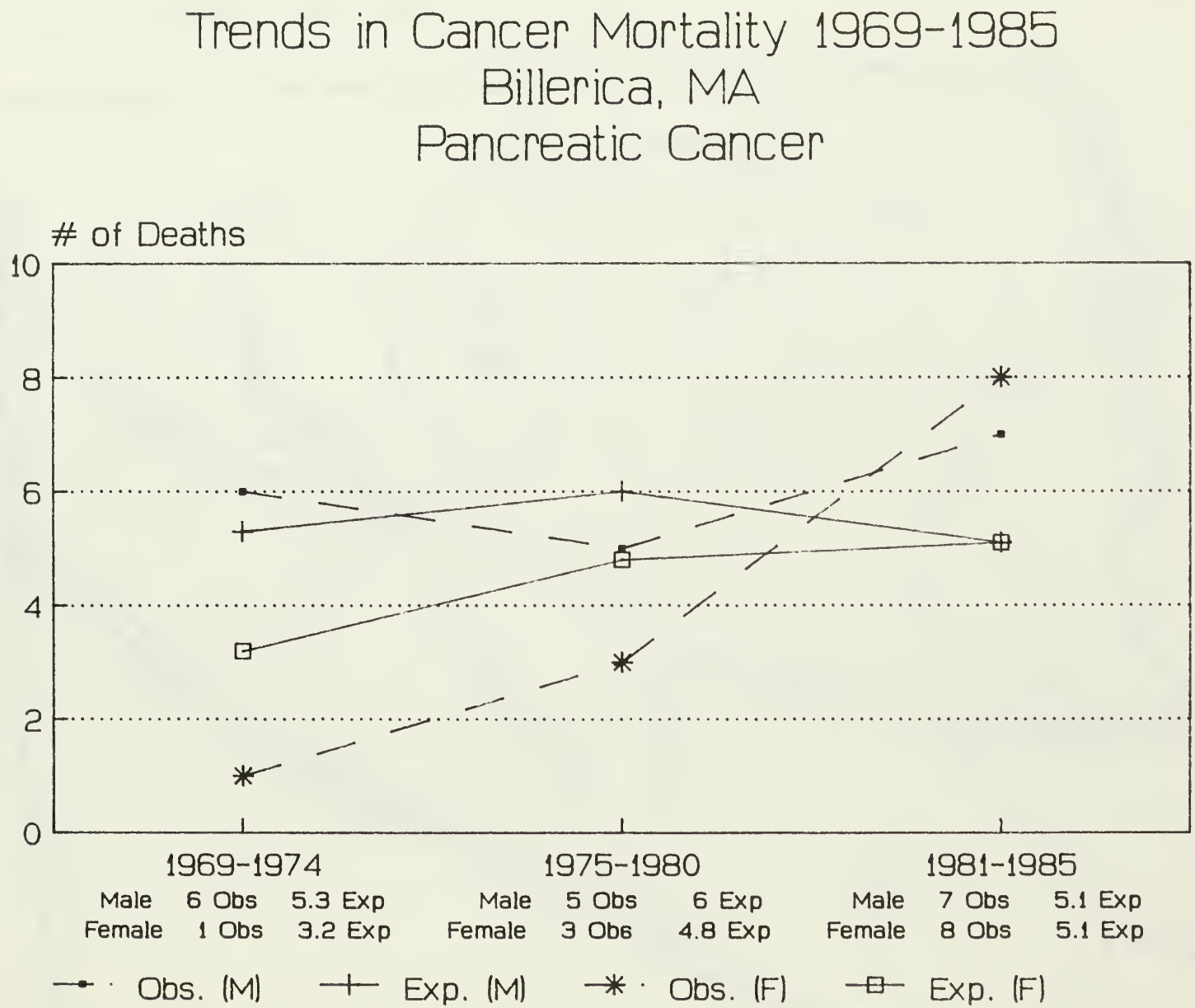
	1969-1974		1975-1980		1981-1985	
	Male	Female	Male	Female	Male	Female
Town	6/5.3=112	1/3.2=31	5/6.0=84	3/4.8=62	7/5.1=137	8/5.1=157
3161	3/1.3=237	1/1.1=91	1/1.5=68	2/1.4=141	1/1.3=77	2/1.5=134
3162	0/1.4=0	0/0.8=0	1/1.4=70	1/0.9=103	4/1.2=347	2/1.0=208
3163	0/0.7=0	0/0.4=0	1/0.9=110	0/0.7=0	0/0.8=0	1/0.8=126
3164	1/0.7=135	0/0.4=0	1/0.8=124	0/0.5=0	2/0.6=323	1/0.5=211
3165	2/1.3=156	0/1.0=0	1/1.4=72	0/1.3=0	0/1.2=0	2/1.4=146

Note: All values rounded and presented as Observed number/Expected number x 100= Standardized Mortality Ratio

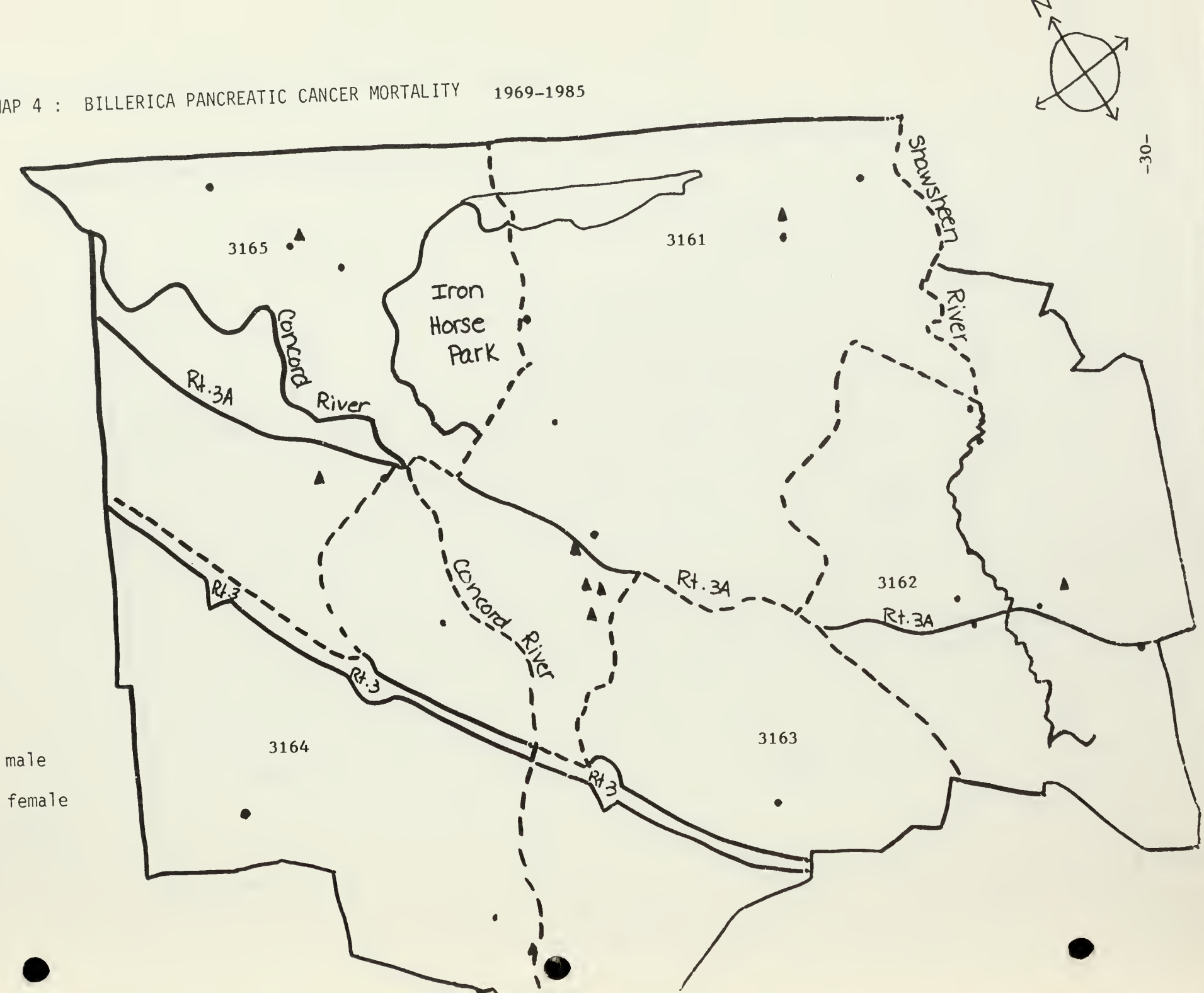
+ or - indicates statistical significance at the 0.05 level
++ or - - indicates statistical significance at the 0.01 level

Statistical significance not calculated where number of deaths is < 5.

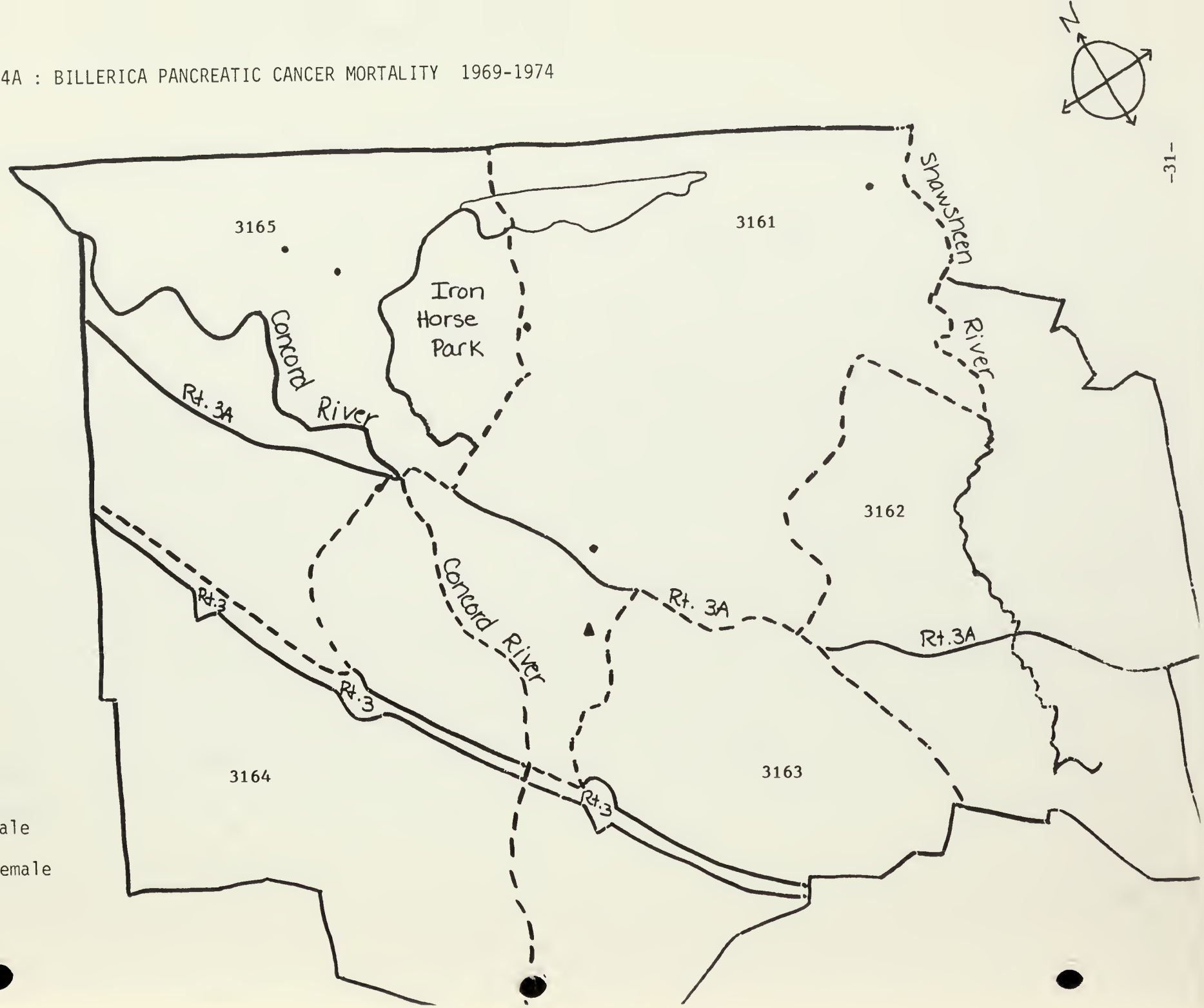
Figure 4


Trends in Cancer Mortality 1969-1985
Billerica, MA
Pancreatic Cancer
# of Deaths
10
8
6
4
2
0
1969-1974
Male 6 Obs 5.3 Exp
Female 1 Obs 3.2 Exp
1975-1980
Male 5 Obs 6 Exp
Female 3 Obs 4.8 Exp
1981-1985
Male 7 Obs 5.1 Exp
Female 8 Obs 5.1 Exp
Obs. (M)
Exp. (M)
Obs. (F)
Exp. (F)

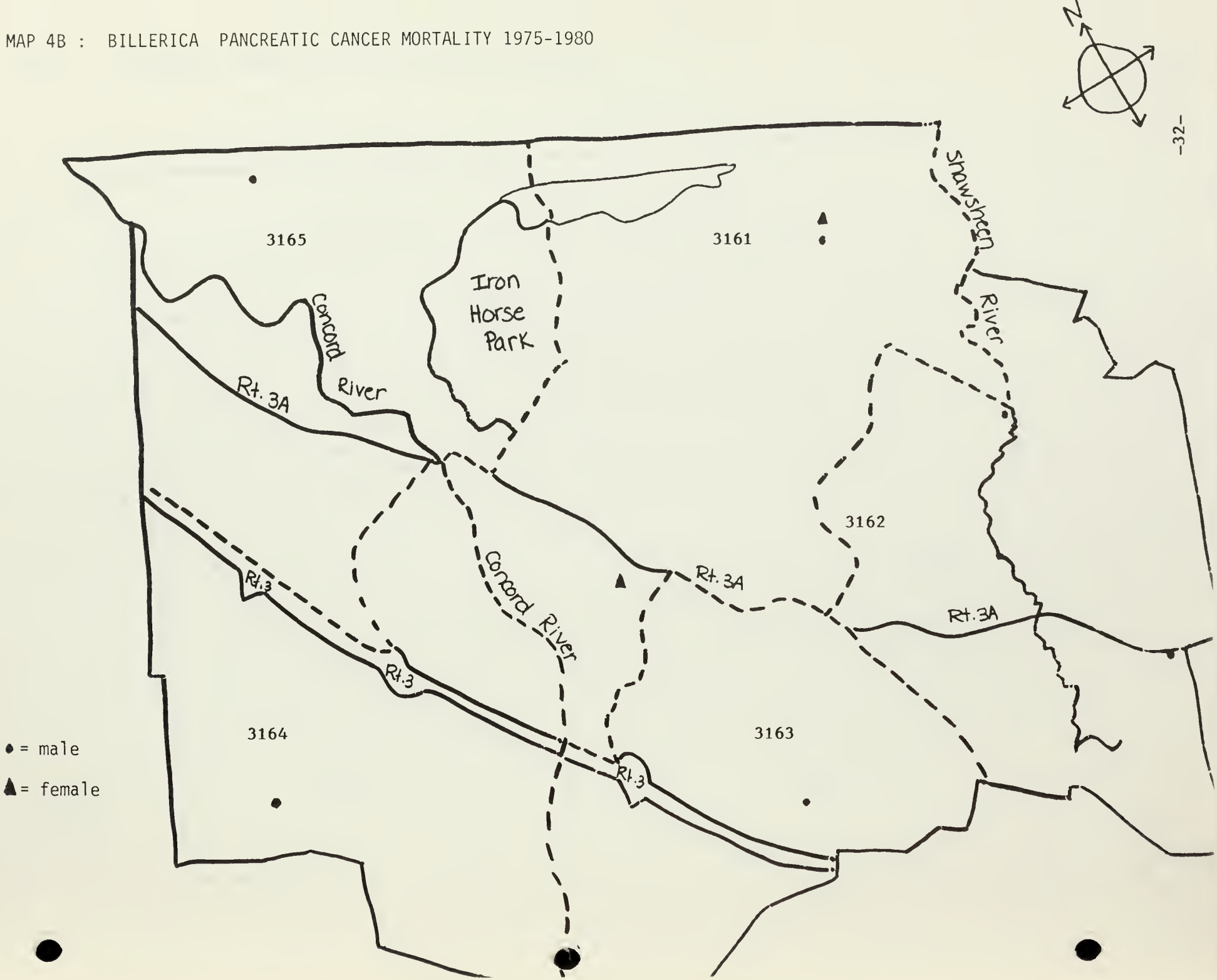
MAP 4 : BILLERICA PANCREATIC CANCER MORTALITY 1969-1985



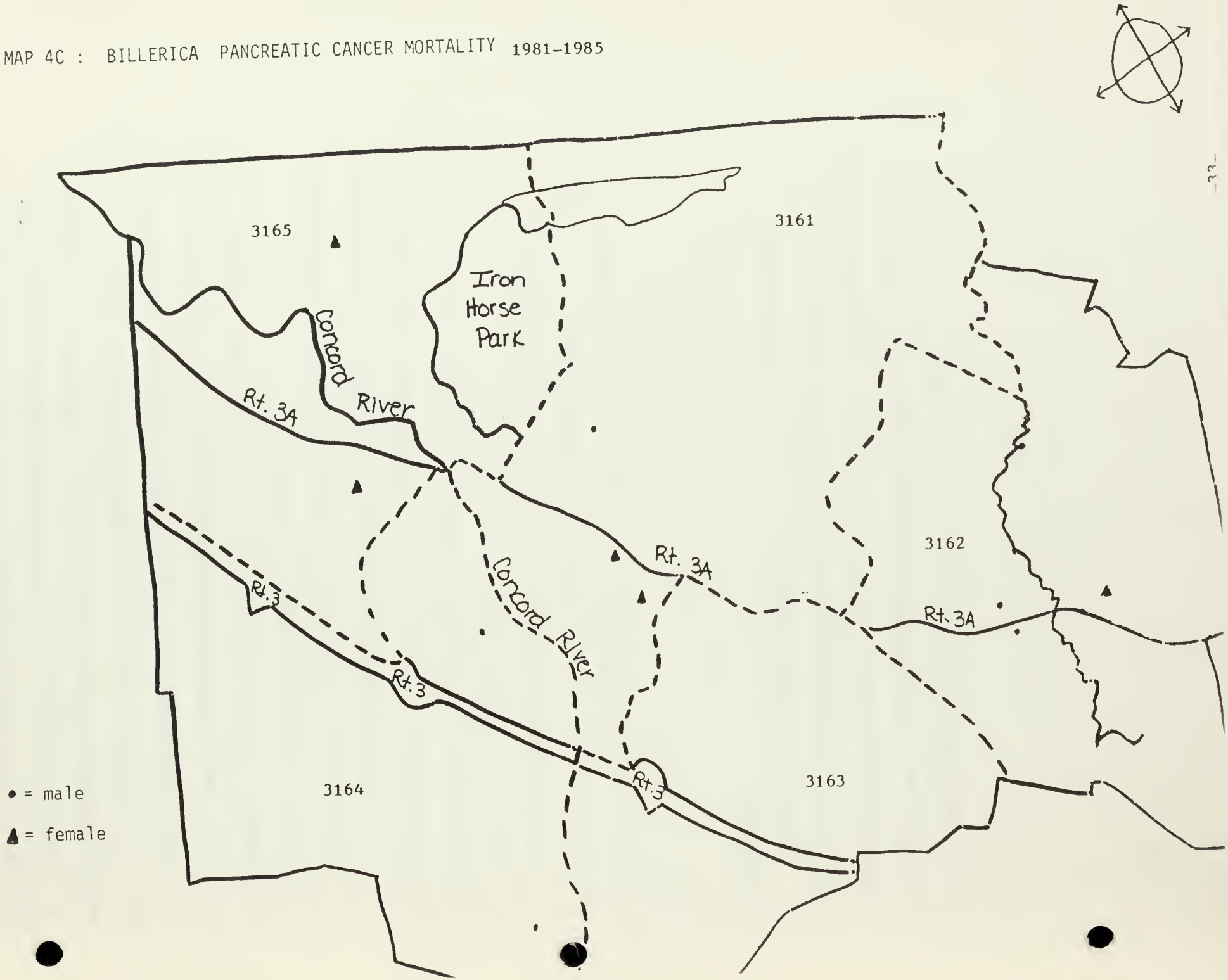
MAP 4A : BILLERICA PANCREATIC CANCER MORTALITY 1969-1974



MAP 4B : BILLERICA PANCREATIC CANCER MORTALITY 1975-1980



MAP 4C : BILLERICA PANCREATIC CANCER MORTALITY 1981-1985



occurred at the rate that was expected (41 observed, 41.5 expected; SMR = 99). Overall, pancreatic cancer mortality was somewhat elevated in both males and females in census tract 3161 (males: 5 observed, 4.1 expected; SMR = 122 females: 5 observed, 4.0 expected; SMR = 125). Census tract 3162 had a slight elevation in male mortality (5 observed, 4.0 expected; SMR = 125), female mortality occurred essentially as often as would have been expected. Male mortality was also elevated in census tract 3164 (4 observed, 2.1 expected; SMR = 190; table 1).

Mortality rates for this type of cancer were elevated in both males and females for the most recent time period (1981-1985). This elevation is most pronounced in census tract 3162. When male and female deaths are combined there is a statistically significant excess in mortality (6 observed, 2.2 expected; SMR = 273, $p = 0.01$).

Geographic mapping indicates what appears to be a concentration of pancreatic mortality in census tract 3161. Though there is not an undue elevation in overall mortality in this census tract, the concentration is still noteworthy.

Lung Cancer:

Overall, lung cancer mortality was elevated for the 17 years investigated (189 deaths observed, 138.7 expected; SMR =136). This elevation is statistically significant ($p < 0.01$). Considered separately, male lung cancer mortality was statistically significantly elevated for the 17 year period (142 observed, 102.1 expected; SMR = 139, $p < 0.01$).

Female lung cancer mortality was also elevated for this same period (47 observed, 36.6 expected; SMR = 128). This elevation was not statistically significant (i.e.: $p > 0.05$; table 1).

With regard to individual census tracts for the same time period, male lung cancer mortality was elevated in all census tracts except 3164. Statistically significant elevations were in census tracts 3161 (38 observed, 25.1 expected; SMR = 151, $p < 0.05$), 3162 (38 observed, 24.4 expected; SMR = 156, $p < 0.01$), and 3165 (36 observed, 23.6 expected; SMR = 153, $p < 0.05$). Female mortality rates were elevated in all census tracts except 3161 and a statistically significant elevation was observed in census tract 3162 (15 observed, 7.9 expected; SMR = 190 $p < 0.05$) (table 1).

When considering the three time periods separately,(table 6, figure 5 and map series 5); during 1969-1974 townwide lung cancer mortality was elevated for both males and females. Higher than expected rates were also observed for both males and females in census tracts 3162, 3163 and 3165. Female lung cancer deaths were also elevated in census tract 3164. Several of the elevations during this time period are based on small excesses and none of the elevations were statistically significant.

For the 6 years from 1975-1980, deaths due to lung cancer were statistically significantly elevated in males townwide ($p < 0.01$) and in census tracts 3161 and 3165 ($p < 0.05$). Elevated rates were observed in census tract 3163 and a slight elevation was observed in 3162. Females also experienced elevated mortality rates in most census tracts (3161, 3162, 3163, and 3164). The excess in census tract 3162 was statistically significant ($p < 0.01$). the townwide excess of female lung cancer mortality was of borderline statistical significance ($p = 0.06$).

During the most recent five year period analyzed (1981-1985) male lung cancer continued to be significantly elevated both on a townwide basis ($p < 0.01$) and in census tracts 3161 ($p < 0.05$) and 3162 ($p < 0.01$). Rates appear to be returning to what would be expected in census tract 3163 where fewer deaths than expected were observed during this time period as compared to the elevation observed during the years 1975-1980, while in census tract 3164 the rate was higher in 1981-1985 than in 1975-1980. Census tract 3165 continued to have an elevated lung cancer mortality rate. Overall, mortality for females was essentially what would have been expected for 1981-1985. Slight elevations were observed in census tracts 3162, 3163, and 3164, while fewer than expected female lung cancer deaths were observed in census tract 3161. Census tract 3165 continued to have more female lung cancer deaths than expected. However, this elevation was not statistically significant. Lung cancer mortality trends for each census tract are presented graphically as figures 5a - e.

Breast Cancer:

Female mortality due to cancer of the breast occurred less frequently than expected townwide during all three time intervals examined. During the 6 years from 1969-1974 the observed number of deaths was statistically significantly less than that which would have been expected ($p < 0.05$). With the exception of census tract 3163 all census tracts experienced fewer deaths due to female breast cancer than would have been expected during the 17 year period examined. The observed number of deaths in census tract 3162 was statistically significantly fewer than the expected number ($p < 0.05$) and the observed to expected ratio in census tract 3161

Table 6

Standardized Mortality Ratios
Lung Cancer
Billerica, MA

	1969-1974		1975-1980		1981-1985	
	Male	Female	Male	Female	Male	Female
Town	36/29.7=121	11/7.2=153	53/36.5=145++	19/12.8=148	53/35.0=148++	17/16.6=102
3161	7/6.9=101	1/2.0=50	16/9.0=177+	5/3.6=137	15/9.2=164+	2/4.8=42
3162	12/7.6=158	3/1.7=179	10/8.7=115	8/2.8=290	16/8.1=199++	4/3.4=118
3163	6/3.9=155	2/0.9=234	9/5.6=160	3/1.9=161	3/6.1=49	3/2.8=109
3164	2/4.2=48*	2/0.9=216	3/5.0=61	2/1.5=132	8/4.4=180	2/1.8=111
3165	10/7.1=140*	3/1.8=169	15/8.4=179+	1/3.1-33	11/8.1=137	6/3.9=155

* = 1 had to be added to each likely census tract of residence due to problems in locating precise address

Note: All values rounded and presented as Observed number/Expected number x 100= Standardized Mortality Ratio

+ or - indicates statistical significance at the 0.05 level
++ or - - indicates statistical significance at the 0.01 level

Statistical significance not calculated where number of deaths is < 5.

Figure 5

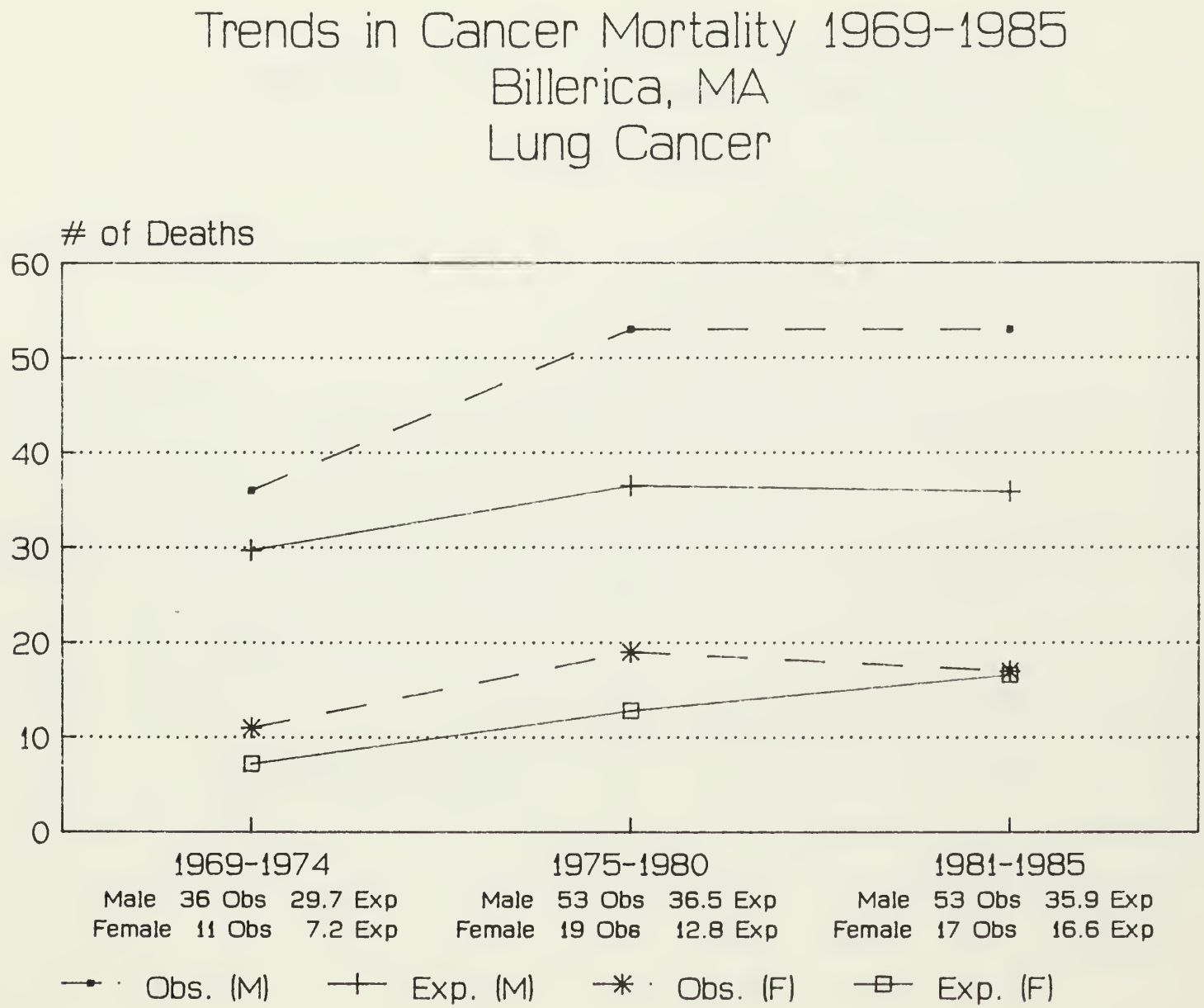

Trends in Cancer Mortality 1969-1985
Billerica, MA
Lung Cancer
# of Deaths
60
50
40
30
20
10
0
1969-1974
Male 36 Obs 29.7 Exp
Female 11 Obs 7.2 Exp
1975-1980
Male 53 Obs 36.5 Exp
Female 19 Obs 12.8 Exp
1981-1985
Male 53 Obs 35.9 Exp
Female 17 Obs 16.6 Exp
Obs. (M)
Exp. (M)
Obs. (F)
Exp. (F)

Figure 5a

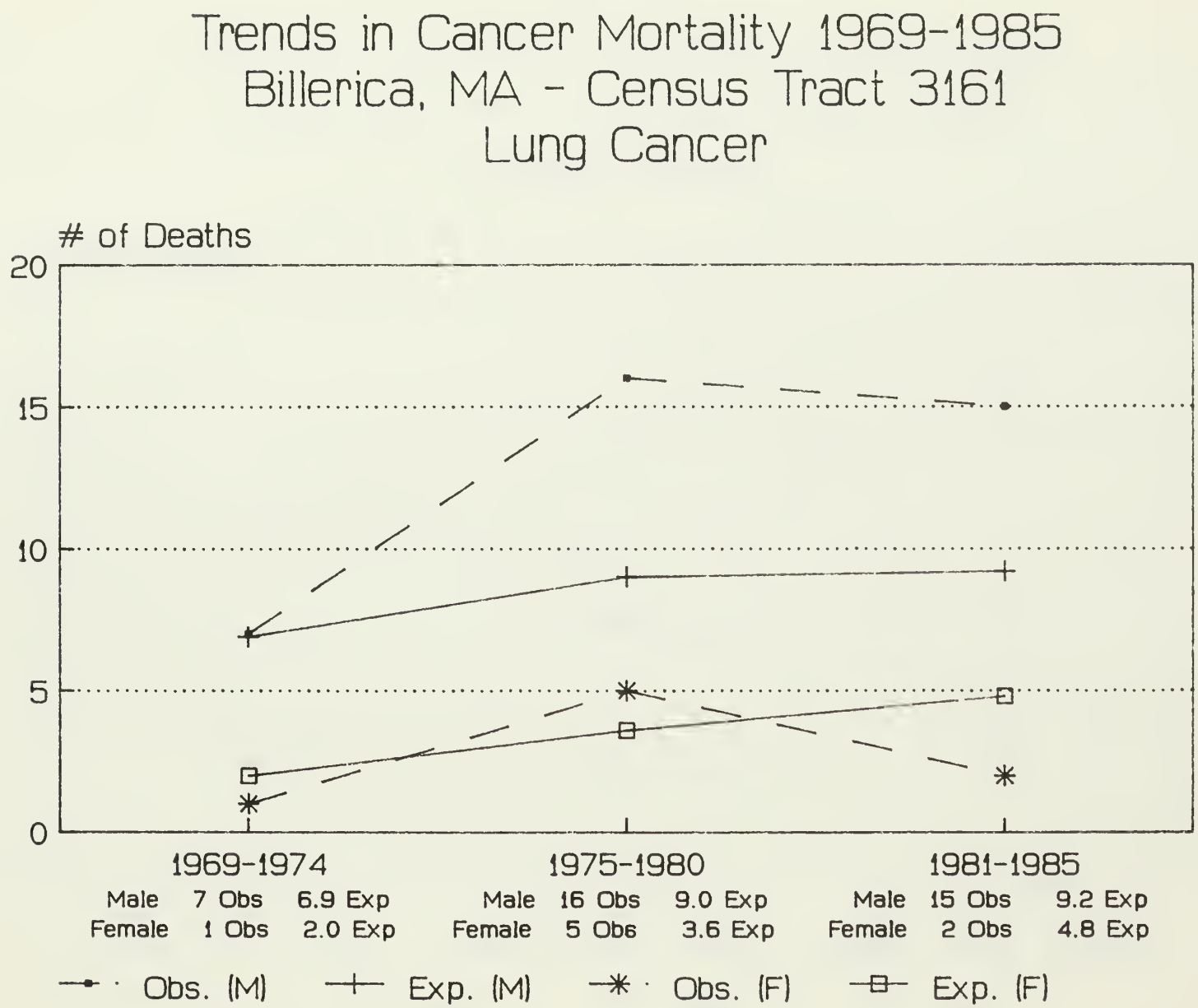

Trends in Cancer Mortality 1969-1985
Billerica, MA - Census Tract 3161
Lung Cancer
# of Deaths
20
15
10
5
0
1969-1974
Male 7 Obs 6.9 Exp
Female 1 Obs 2.0 Exp
1975-1980
Male 16 Obs 9.0 Exp
Female 5 Obs 3.6 Exp
1981-1985
Male 15 Obs 9.2 Exp
Female 2 Obs 4.8 Exp
Obs. (M)
Exp. (M)
Obs. (F)
Exp. (F)

Figure 5b

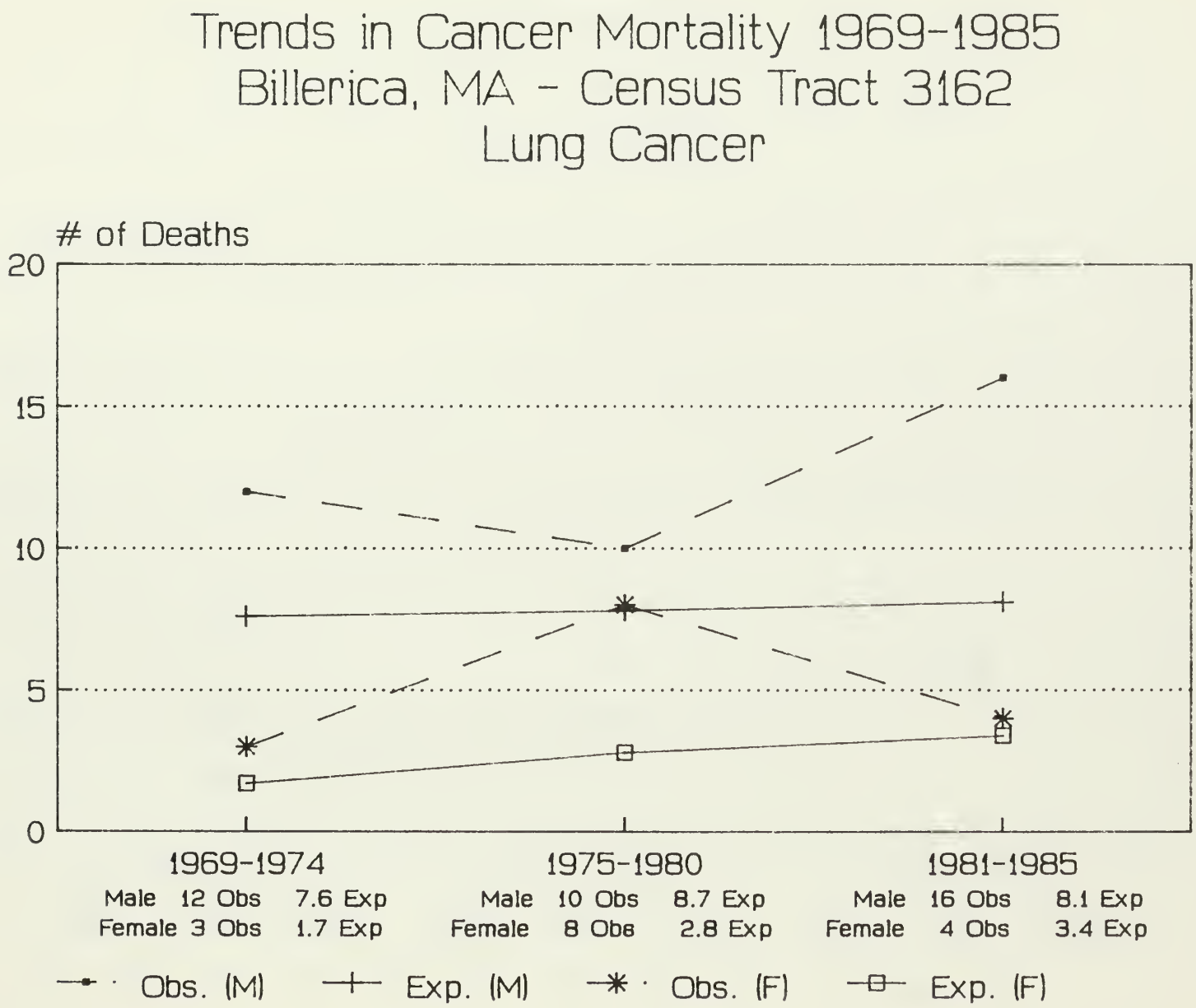

Trends in Cancer Mortality 1969-1985
Billerica, MA - Census Tract 3162
Lung Cancer
# of Deaths
20
15
10
5
0
1969-1974
Male 12 Obs 7.6 Exp
Female 3 Obs 1.7 Exp
1975-1980
Male 10 Obs 8.7 Exp
Female 8 Obs 2.8 Exp
1981-1985
Male 16 Obs 8.1 Exp
Female 4 Obs 3.4 Exp
Obs. (M)
Exp. (M)
Obs. (F)
Exp. (F)

Figure 5c

Trends in Cancer Mortality 1969-1985
Billerica, MA - Census Tract 3163
Lung Cancer

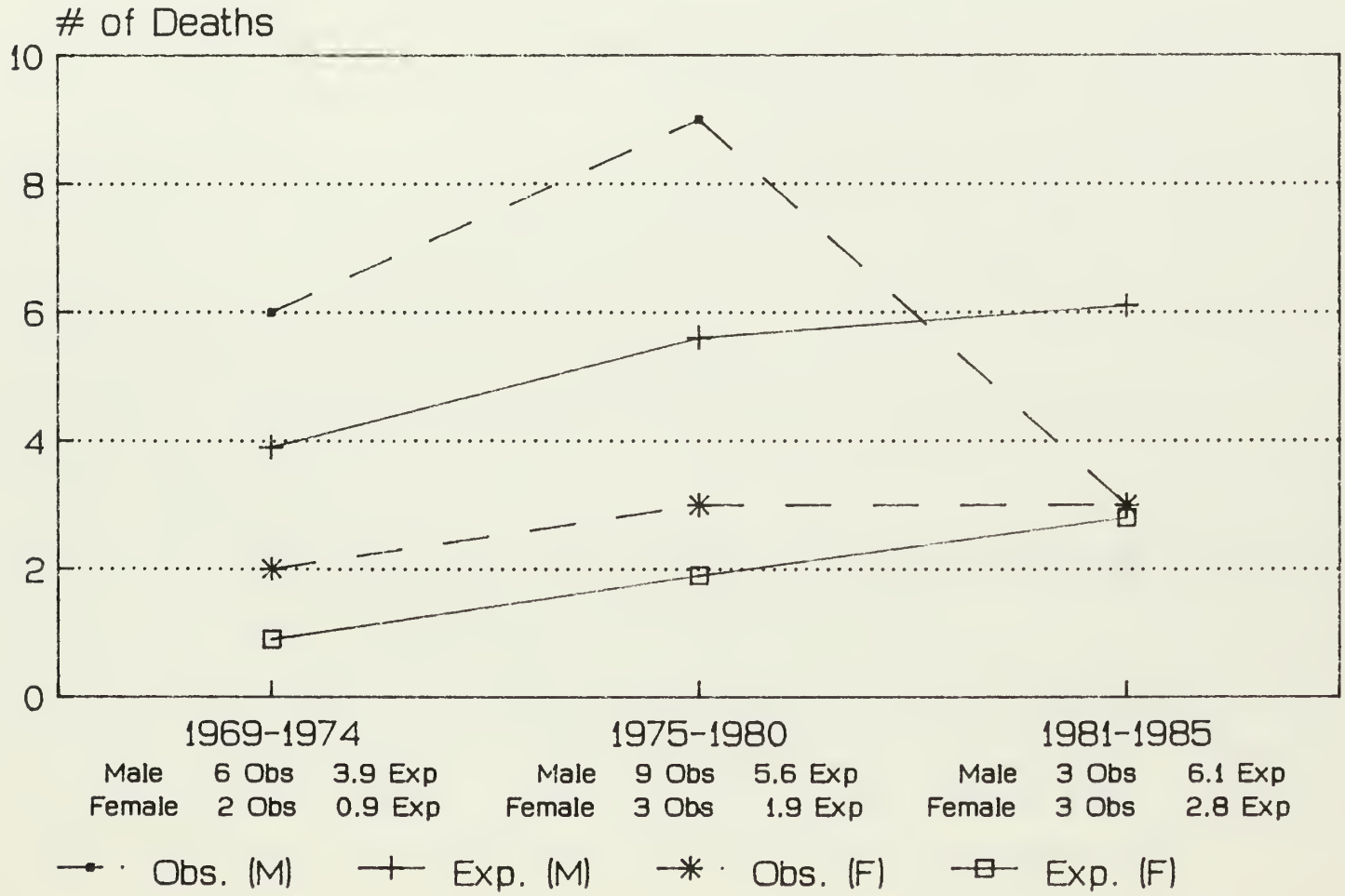


Figure 5d

Trends in Cancer Mortality 1969-1985
Billerica, MA - Census Tract 3164
Lung Cancer

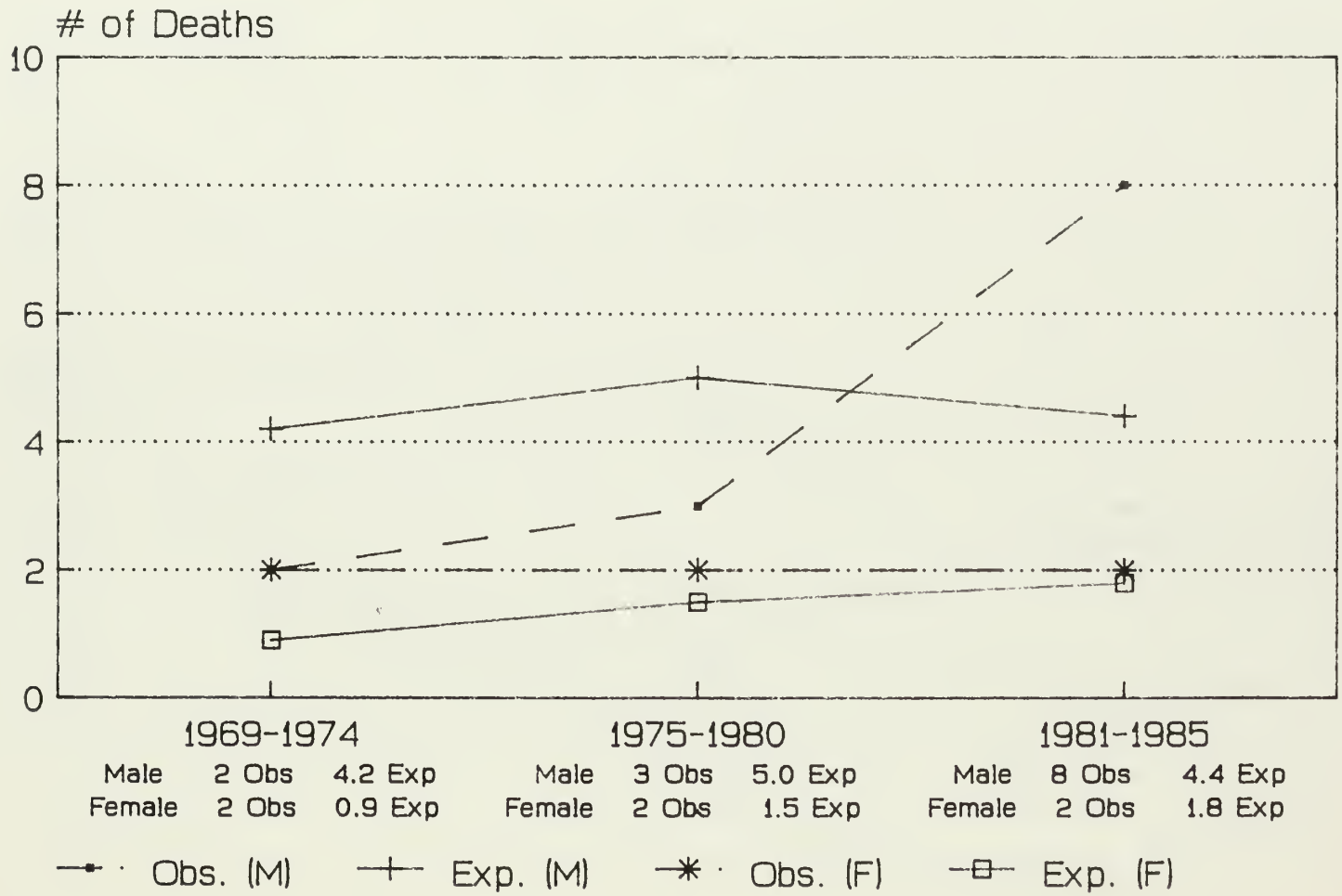
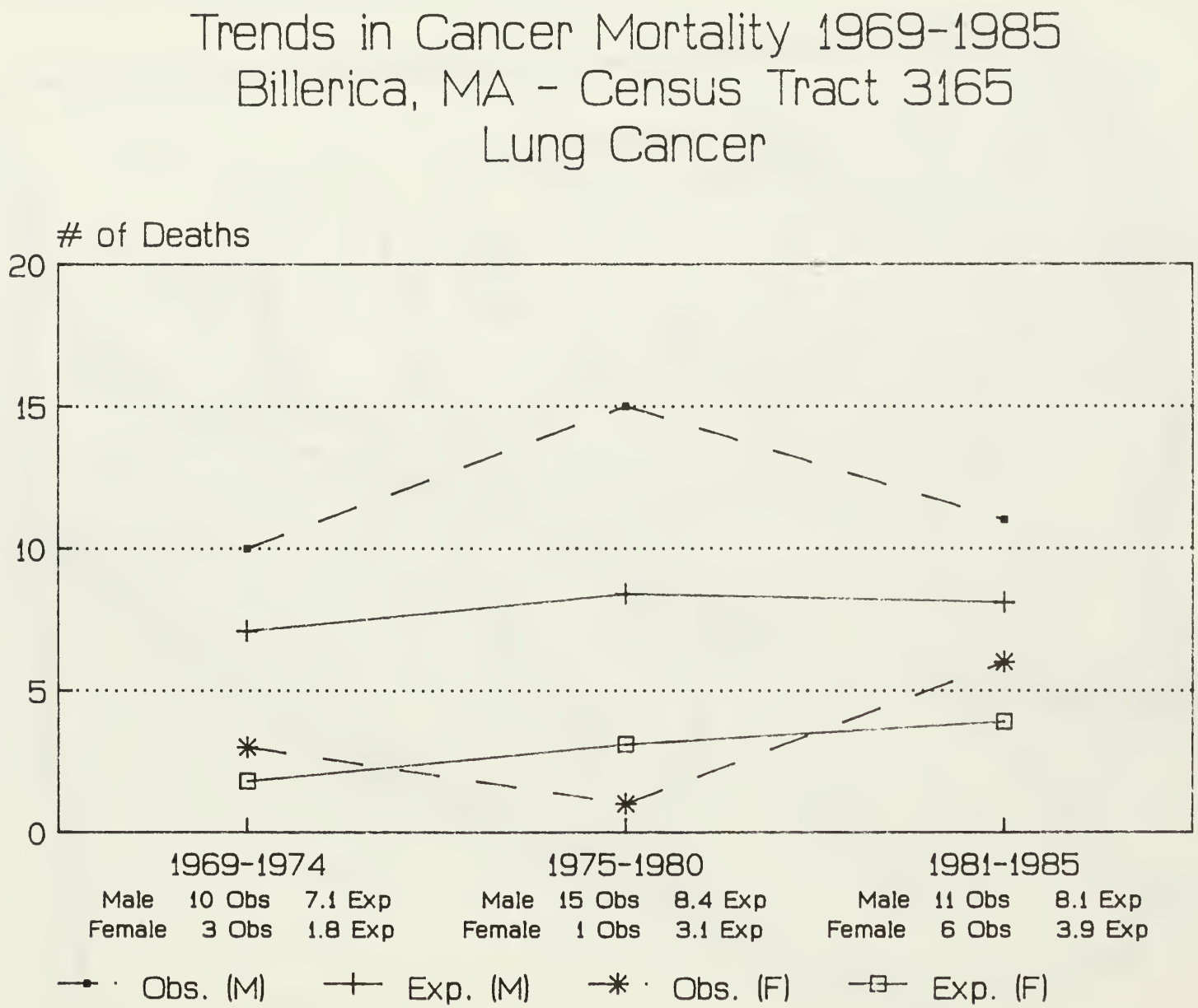
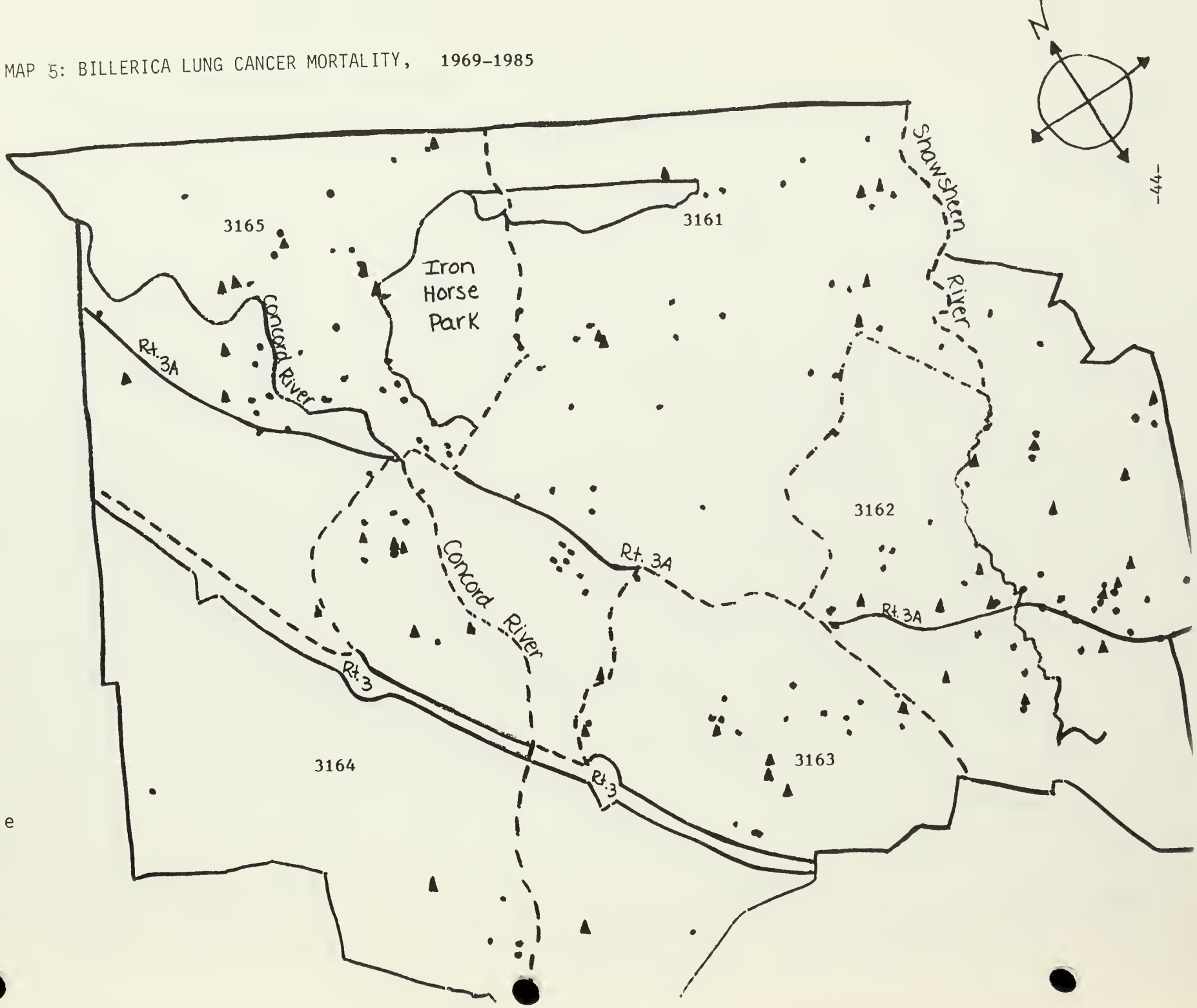


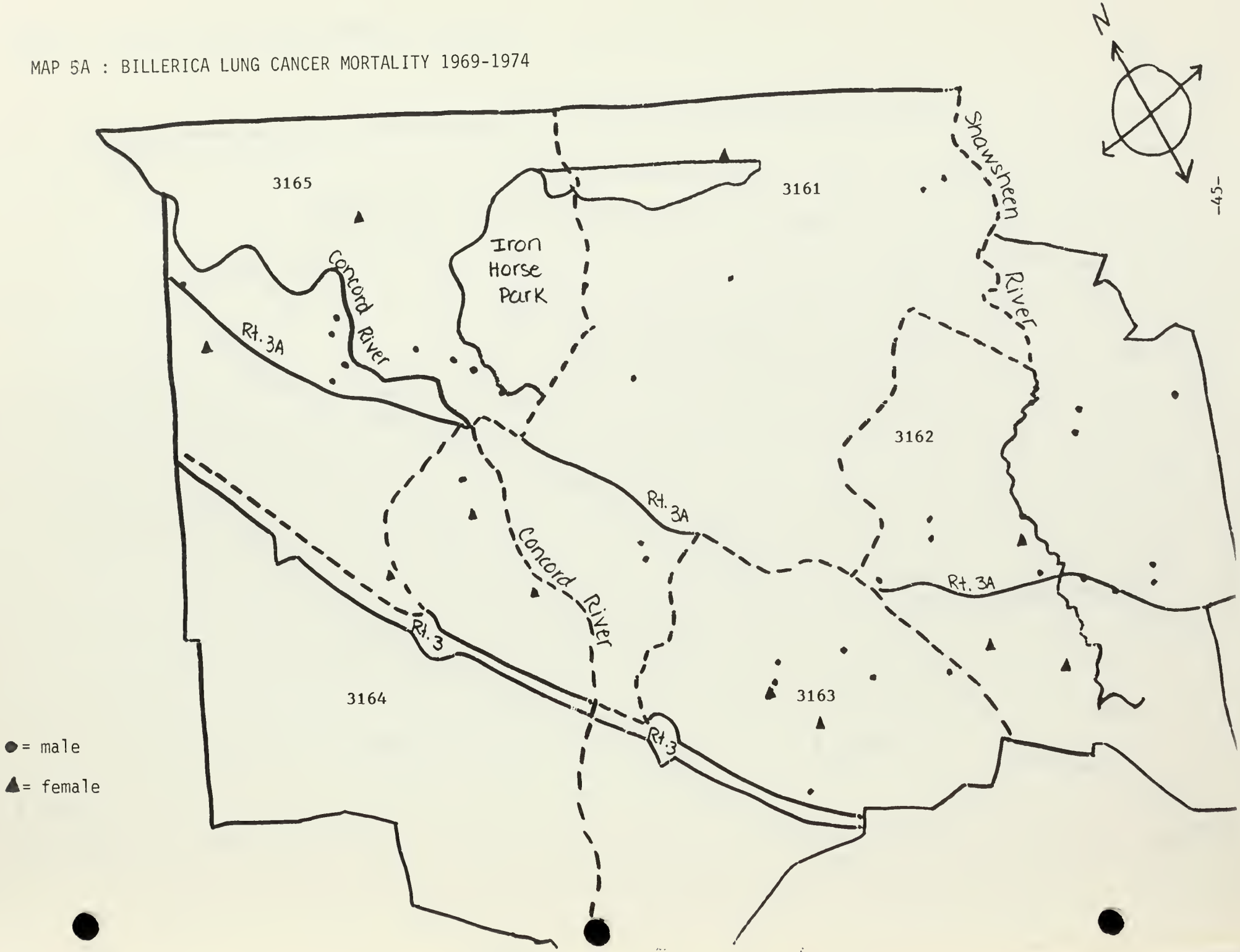
Figure 5e


Trends in Cancer Mortality 1969-1985
Billerica, MA - Census Tract 3165
Lung Cancer
# of Deaths
20
15
10
5
0
1969-1974
Male 10 Obs 7.1 Exp
Female 3 Obs 1.8 Exp
1975-1980
Male 15 Obs 8.4 Exp
Female 1 Obs 3.1 Exp
1981-1985
Male 11 Obs 8.1 Exp
Female 6 Obs 3.9 Exp
Obs. (M)
Exp. (M)
Obs. (F)
Exp. (F)

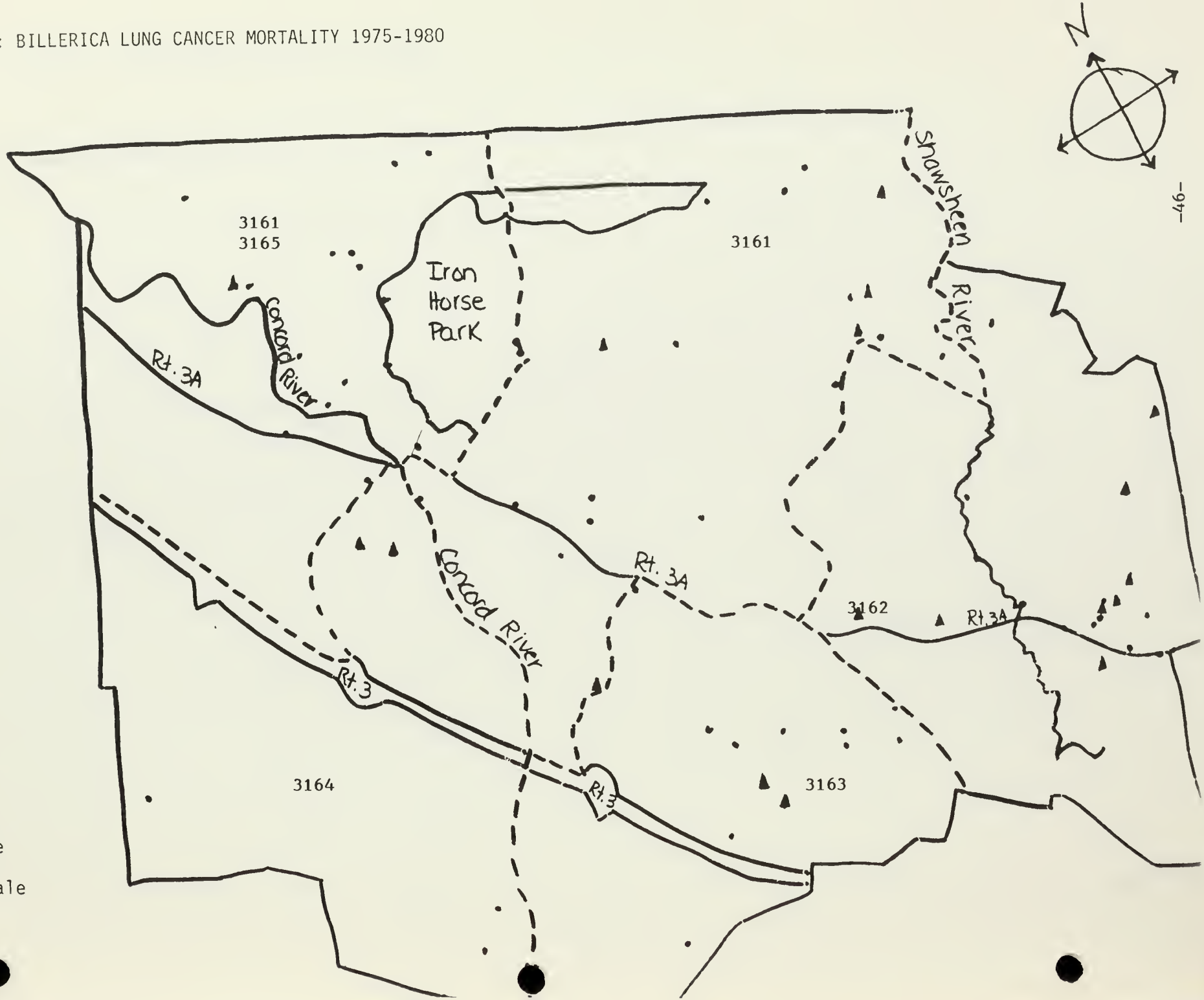
MAP 5: BILLERICA LUNG CANCER MORTALITY, 1969-1985



MAP 5A : BILLERICA LUNG CANCER MORTALITY 1969-1974



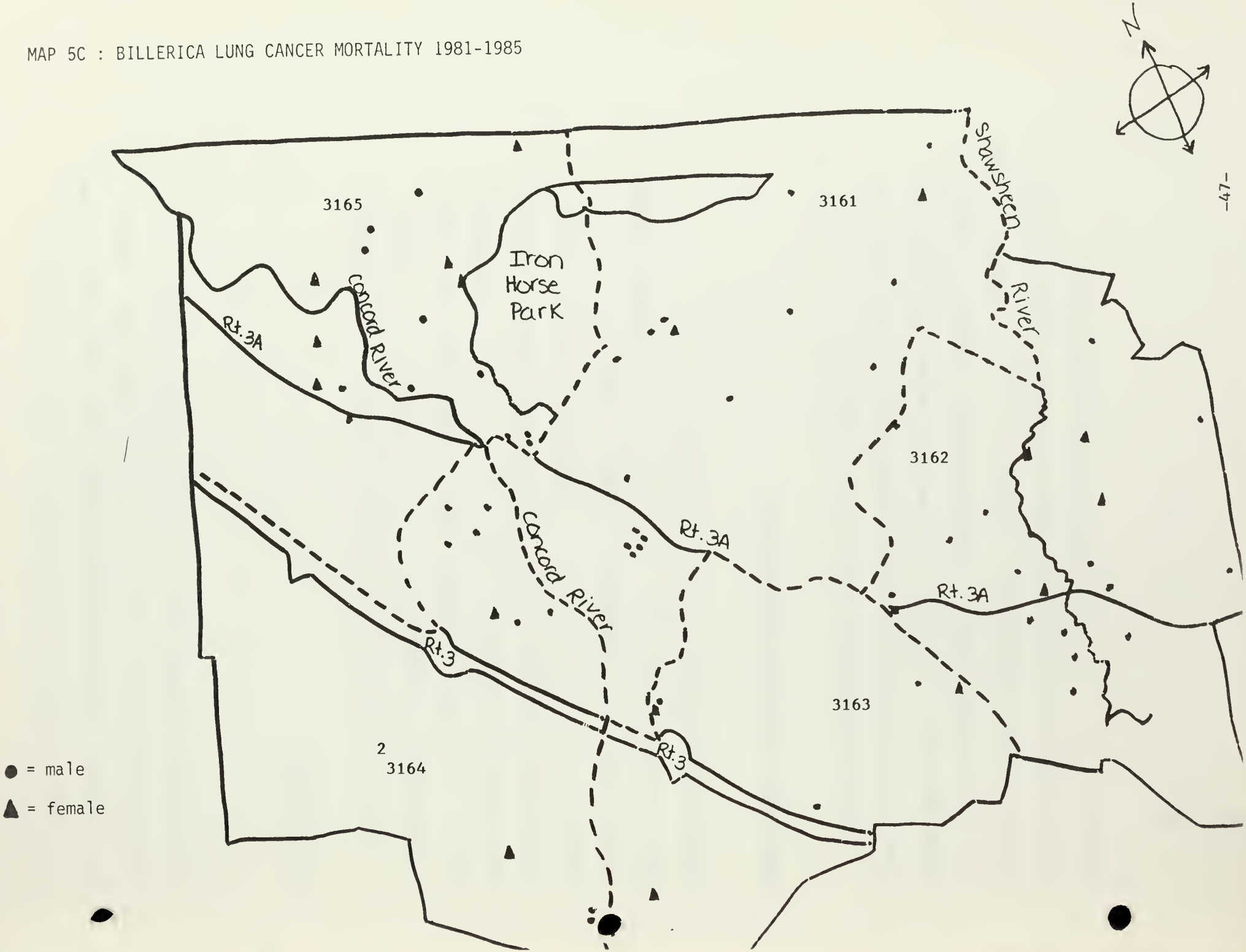
MAP 5B : BILLERICA LUNG CANCER MORTALITY 1975-1980



● = male

▲ = female

MAP 5C : BILLERICA LUNG CANCER MORTALITY 1981-1985



is of borderline statistical significance ($p = 0.06$) for the entire 17 years (table 1). Slight elevations in female breast cancer mortality were observed in census tract 3163 during 1975-1980 and 1981-1985. Census tract 3165 had an elevated rate for 1981-1985 (table 7, figure 6, map series 6).

Cervical Cancer:

Townwide, mortality due to cancers of the uterine cervix occurred slightly more often than expected for the entire 17 year time period (table 1). This slight increase is due to a slight excess in cervical cancer mortality in census tract 3162. For the individual time periods town mortality rates were slightly elevated during 1969-1974 and again in 1975-1980. Since expected numbers for individual census tracts with respect to each time period were quite small -- usually less than one death -- any census tract where 1 death due to cervical cancer occurred appears elevated (table 8, figure 7, map series 7).

Other Female Reproductive Organ Cancers:

Overall, mortality due to other female reproductive organ cancers was observed less often than expected for 1969-1985. With the exception of census tract 3164, all census tracts had fewer deaths than expected for the 17 years studied (table 1). There are several elevations in specific census tracts with regard to the individual time periods, however, as with cervical cancer most of these are based on very small numbers of deaths. Census tract 3164 is the only census tract where the rate stays

Table 7

Standardized Mortality Ratios
Breast Cancer
Billerica, MA

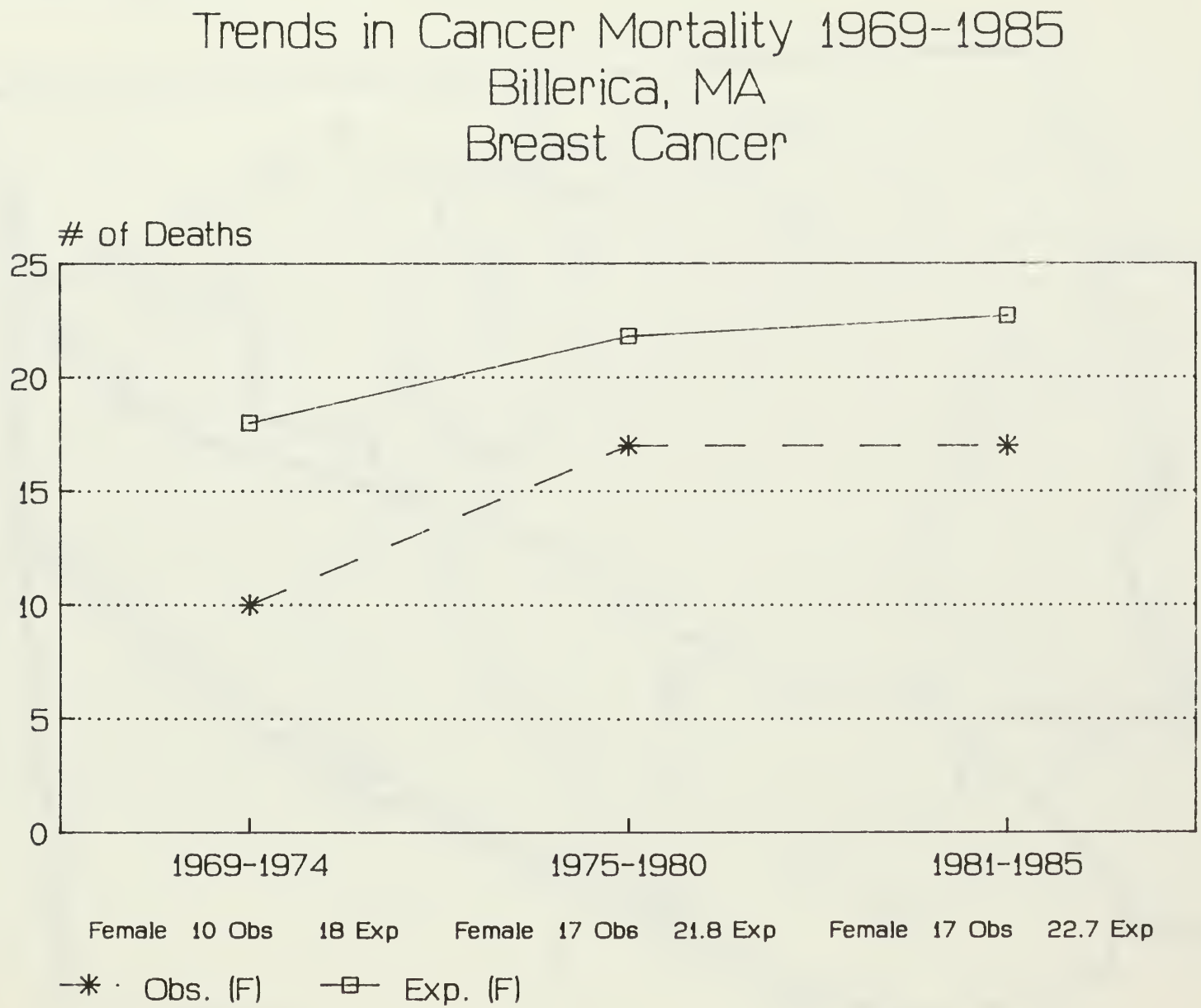
	1969-1974	1975-1980	1981-1985
	Female	Female	Female
Town	10/18=56 -	17/21.8=78	17/22.7=75
3161	3/ 5.0=60	3/ 6.3=48	4/ 6.7=60
3162	2/ 4.2=48	4/ 4.6=87	0/ 4.5=0
3163	2/ 2.1=94	5/ 3.1=160	4/ 3.6=111
3164	2/ 2.3=86	2/ 2.6=78	2/ 2.5=80
3165	1/ 2.7=38	3/ 5.2=58	7/ 5.4=131

Note: All values rounded and presented as Observed number/Expected number x 100= Standardized Mortality Ratio

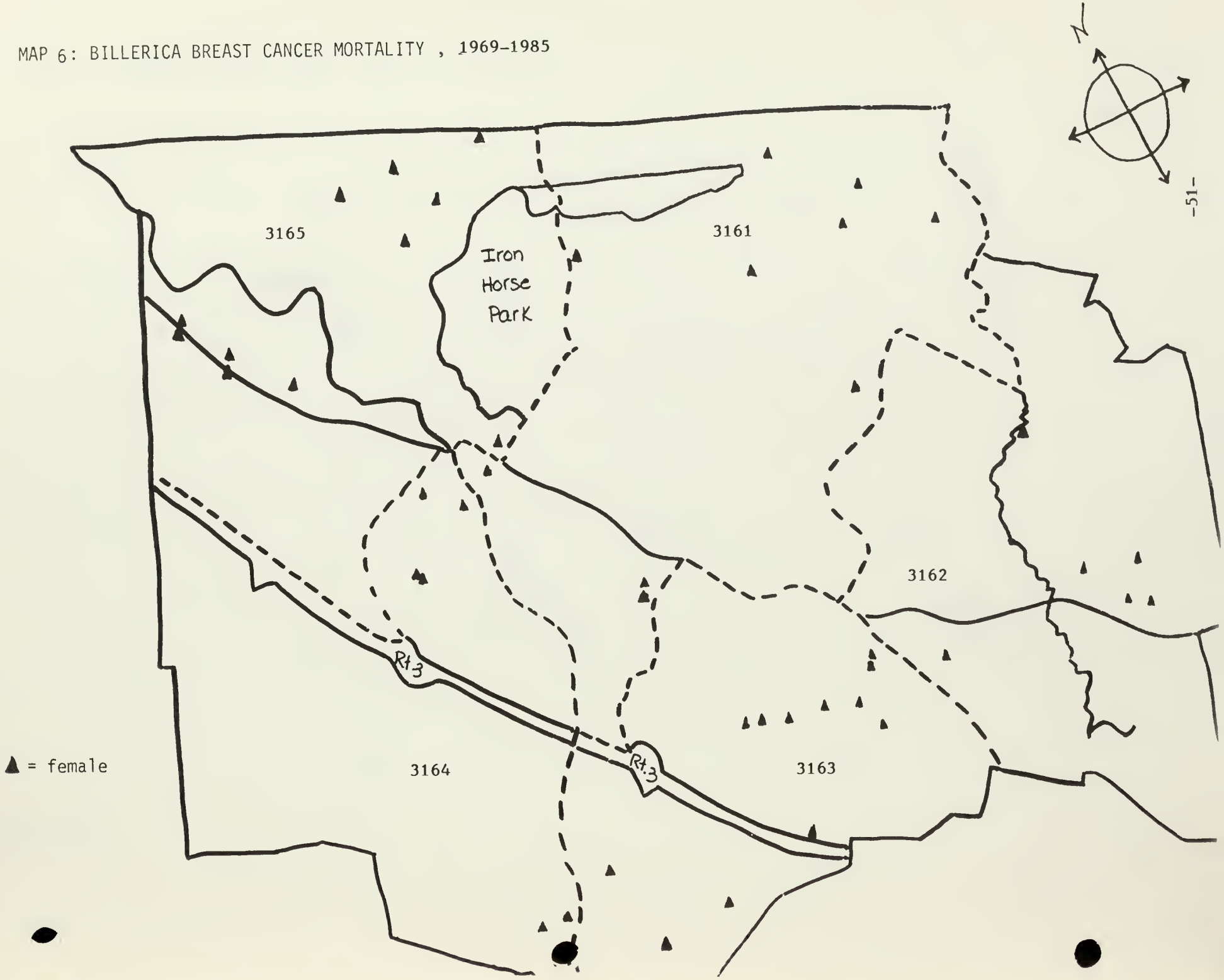
+ or - indicates statistical significance at the 0.05 level
++ or - - indicates statistical significance at the 0.01 level

Statistical significance not calculated where number of deaths is < 5.

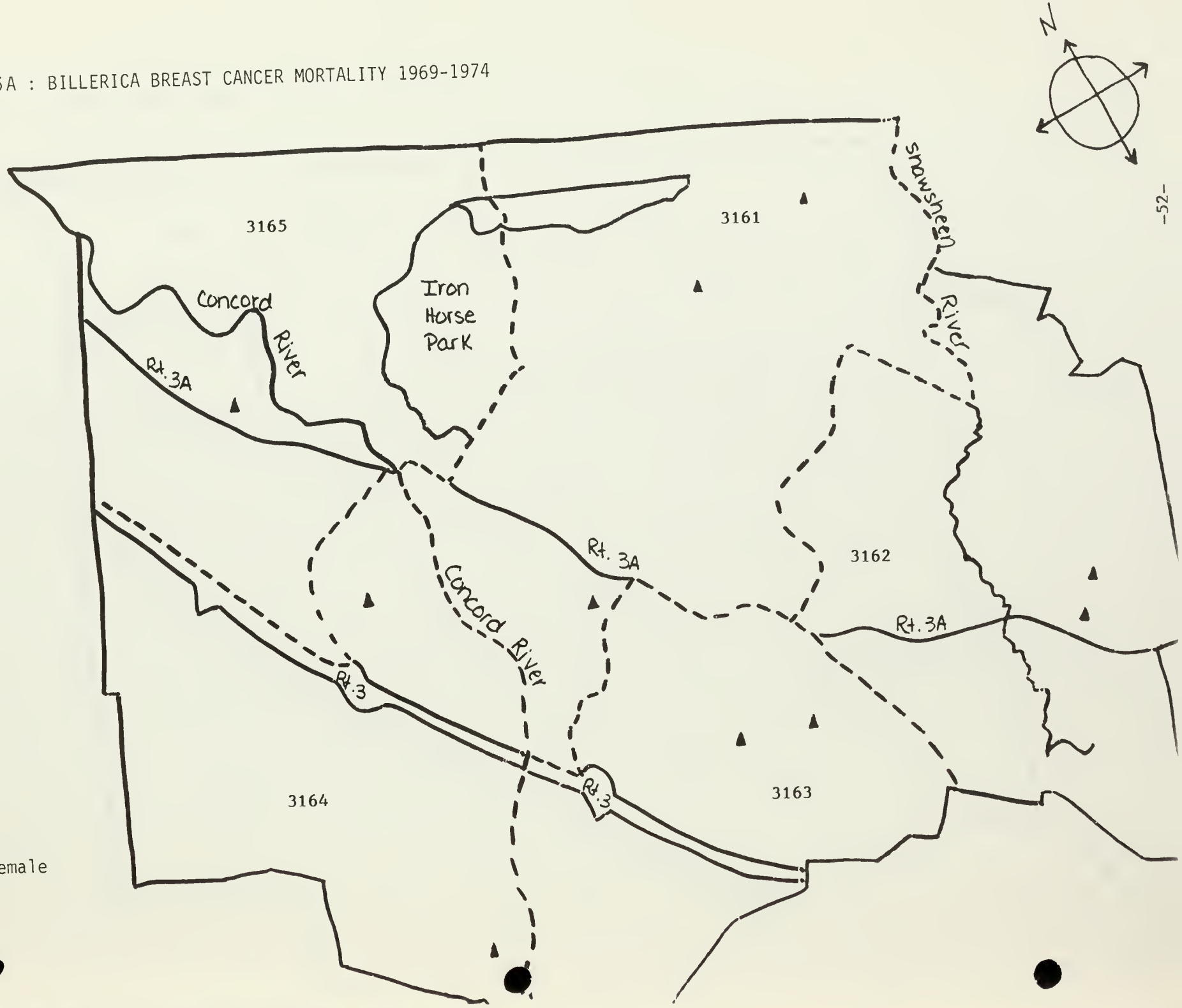
Figure 6


Trends in Cancer Mortality 1969-1985
Billerica, MA
Breast Cancer
# of Deaths
25
20
15
10
5
0
1969-1974
1975-1980
1981-1985
Female 10 Obs 18 Exp
Female 17 Obs 21.8 Exp
Female 17 Obs 22.7 Exp
Obs. (F)
Exp. (F)

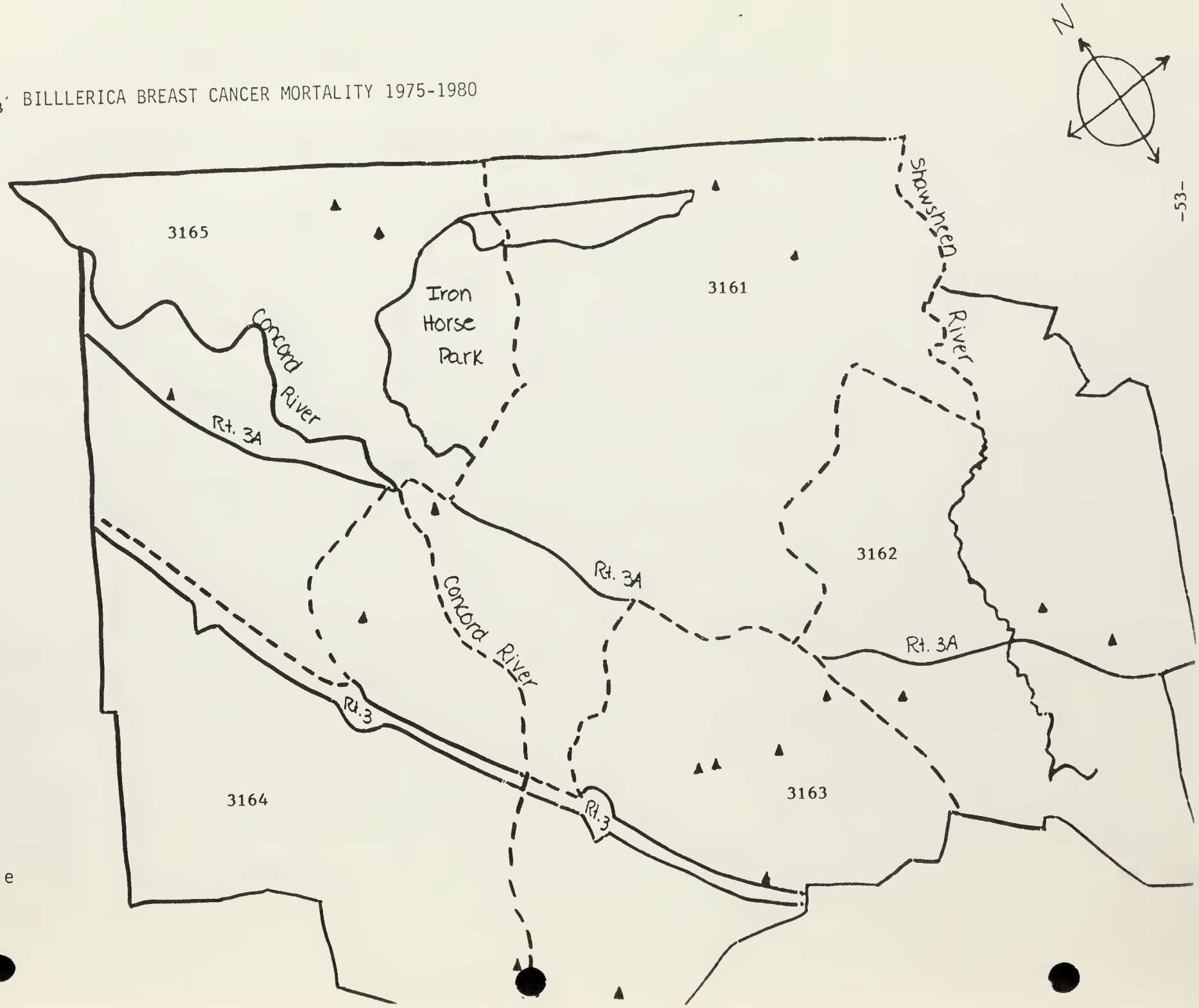
MAP 6: BILLERICA BREAST CANCER MORTALITY , 1969-1985



MAP 6A : BILLERICA BREAST CANCER MORTALITY 1969-1974



MAP 6_B: BILLLERICA BREAST CANCER MORTALITY 1975-1980



MAP 6 C : BILLERICA BREAST CANCER MORTALITY 1981-1985

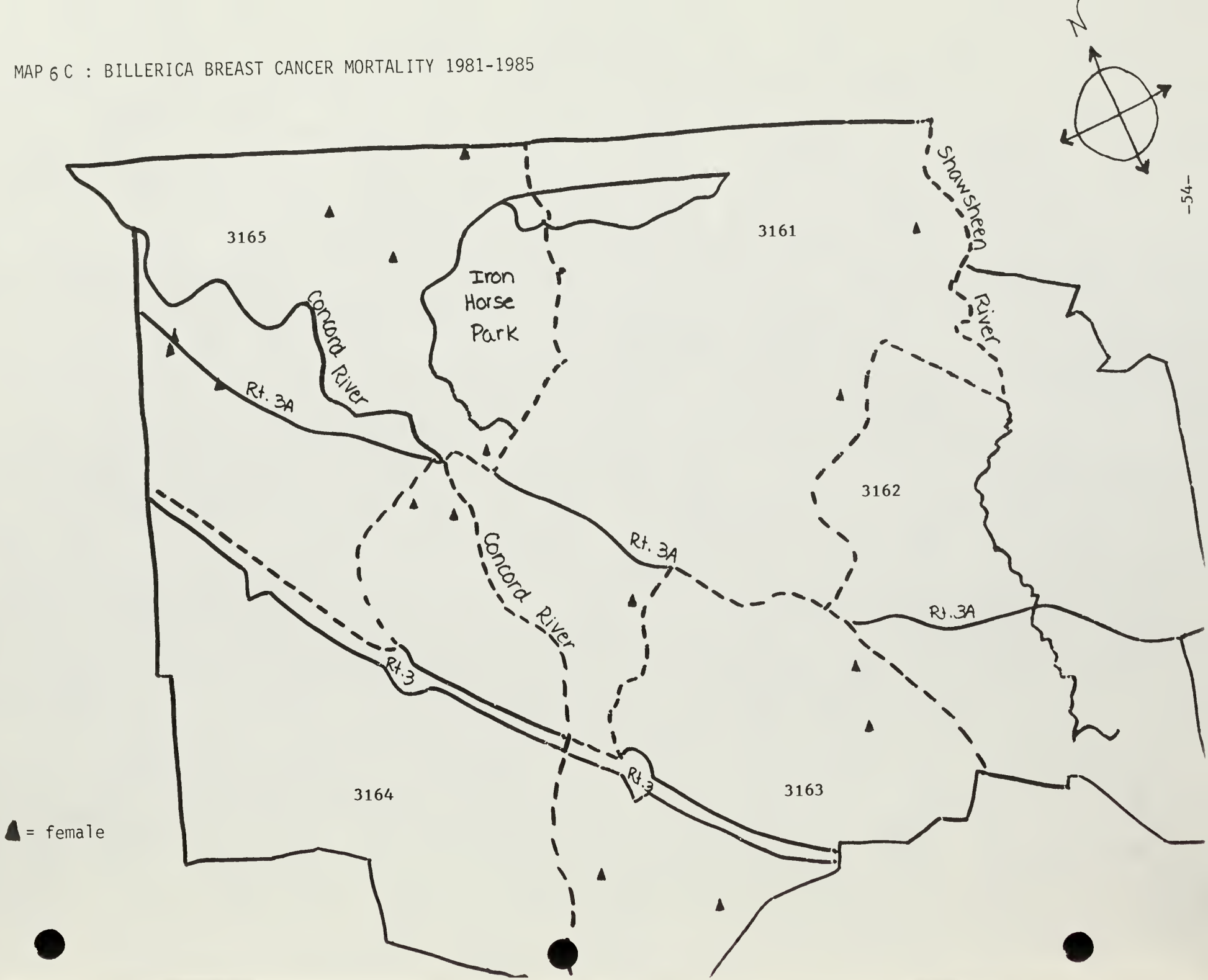


Table 8

Standardized Mortality Ratios
Cervix
Billerica, MA

	1969-1974	1975-1980	1981-1985
	Female	Female	Female
Town	4/2.9=136	3/2.5=119	1/2.1=47
3161	2/0.8=245	0/0.7=0	0/0.6=0
3162	1/0.7=145	1/0.5=185	1/0.4=235
3163	0/0.5=0	1/0.4=276	0/0.3=0
3164	0/0.4=0	1/0.3=318	0/0.3=0
3165	1/0.7=145	0/0.6=0	0/0.5=0

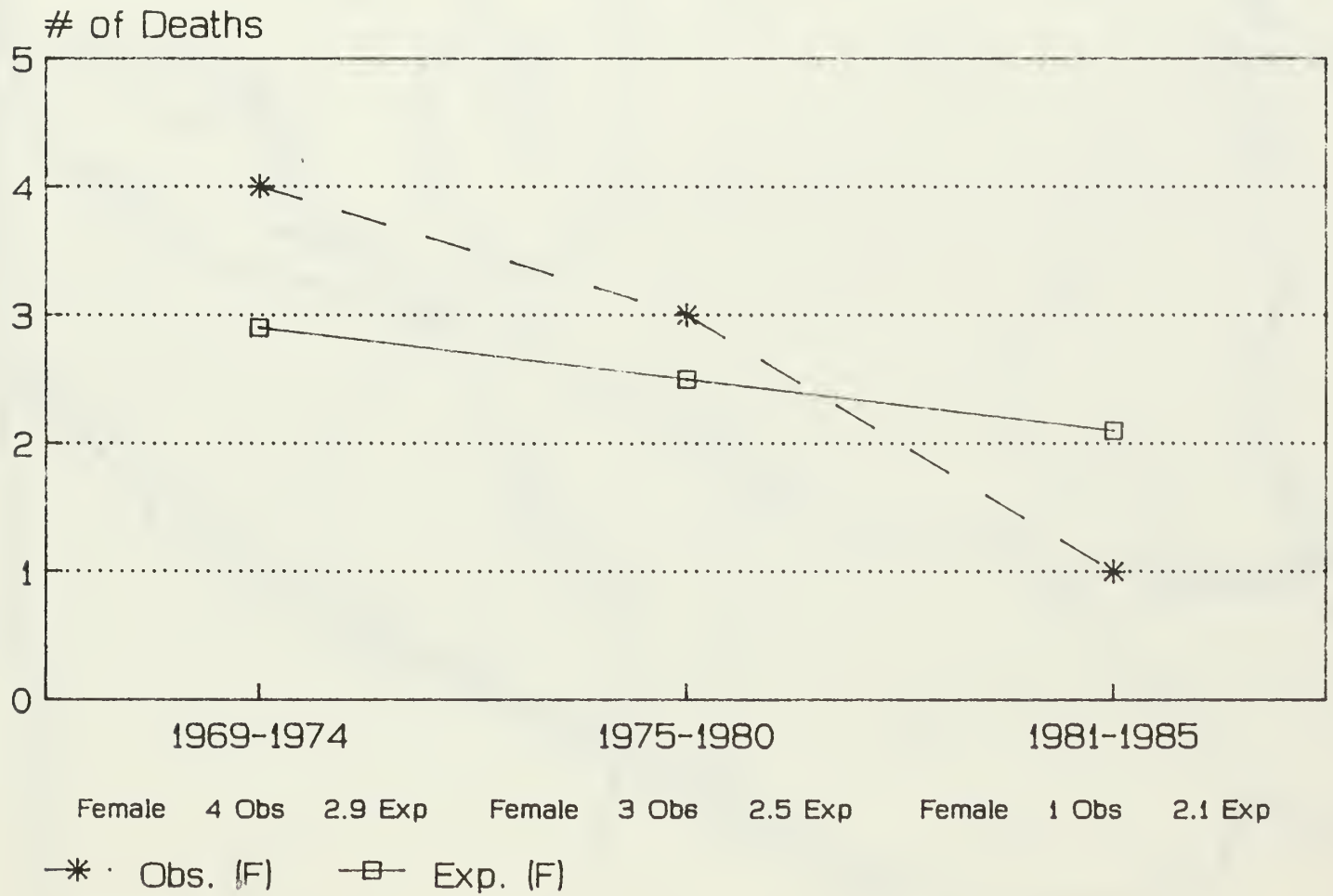
Note: All values rounded and presented as Observed number/Expected number x 100= Standardized Mortality Ratio

+ or - indicates statistical significance at the 0.05 level
++ or - - indicates statistical significance at the 0.01 level

Statistical significance not calculated where number of deaths is < 5.

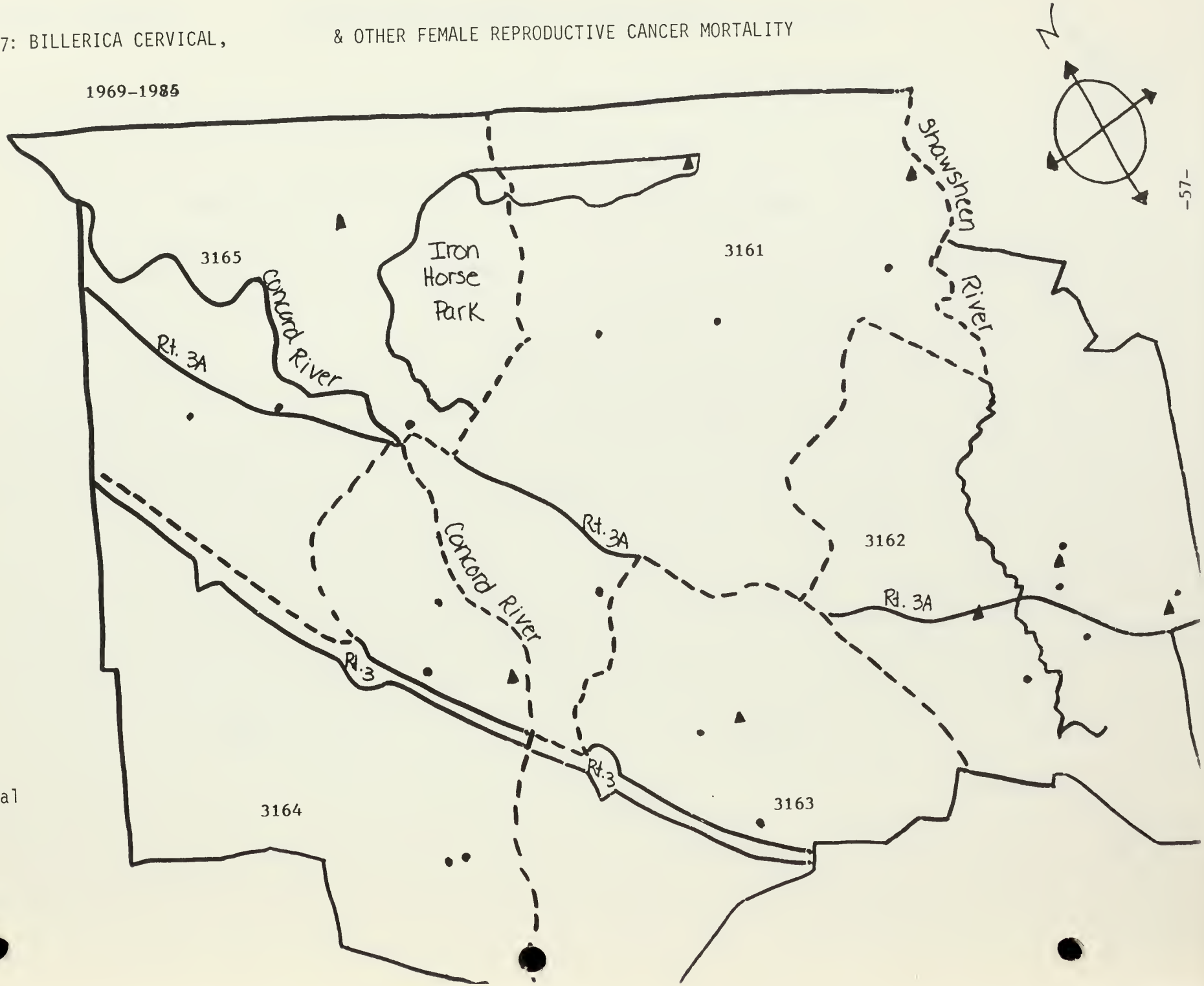
Figure 7

Trends in Cancer Mortality 1969-1985
Billerica, MA
Cervical Cancer

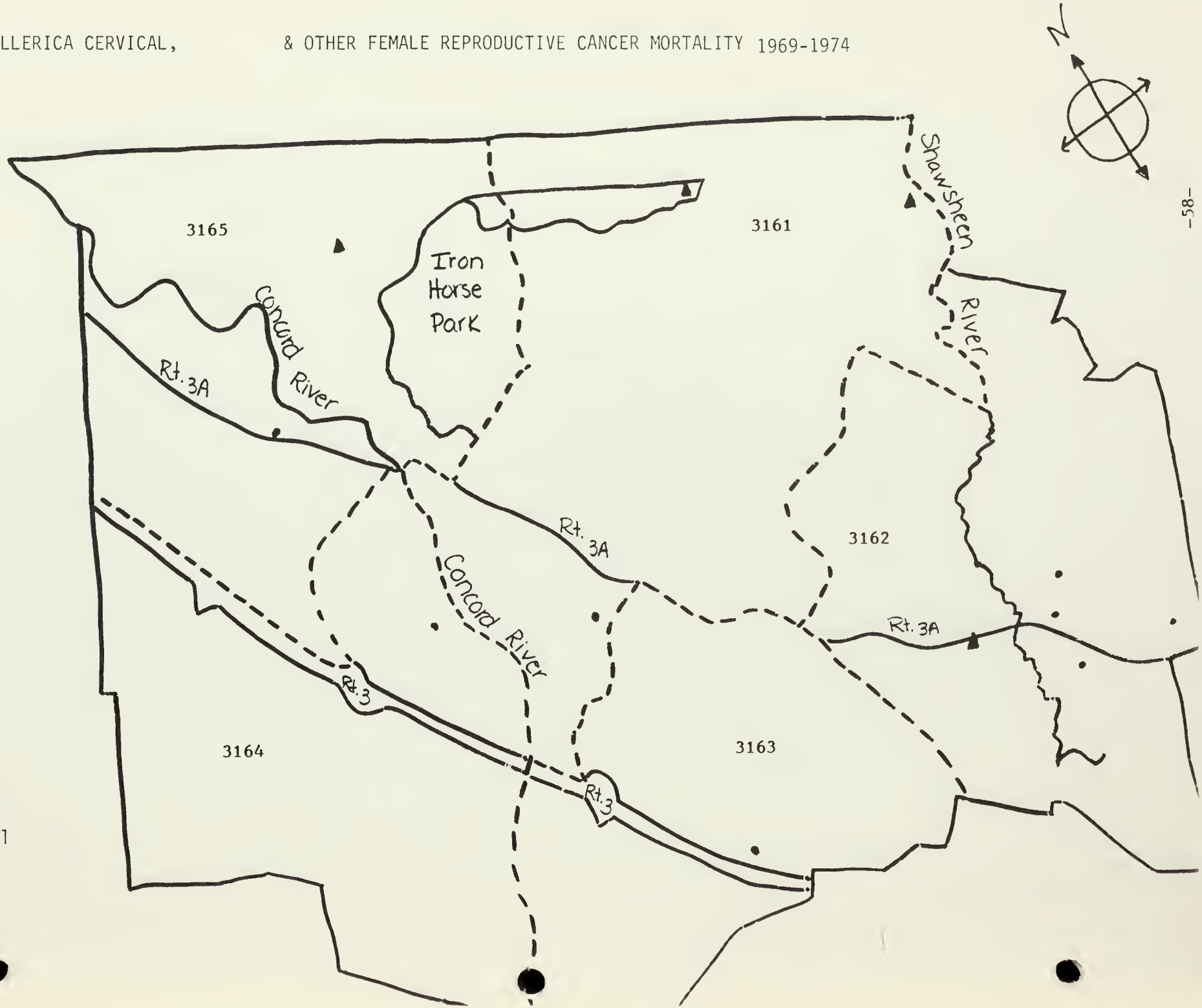


MAP 7: BILLERICA CERVICAL, & OTHER FEMALE REPRODUCTIVE CANCER MORTALITY

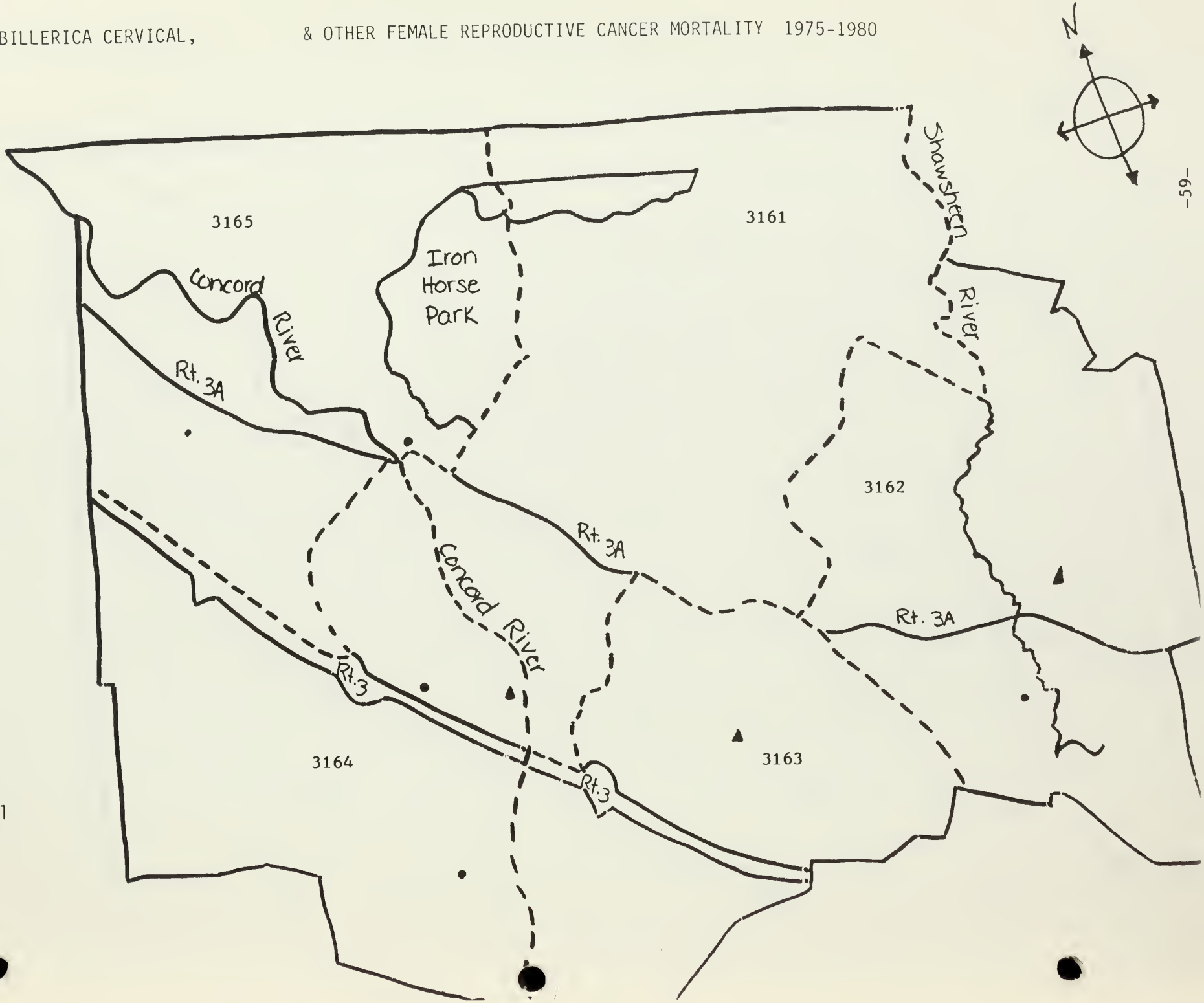
1969-1985



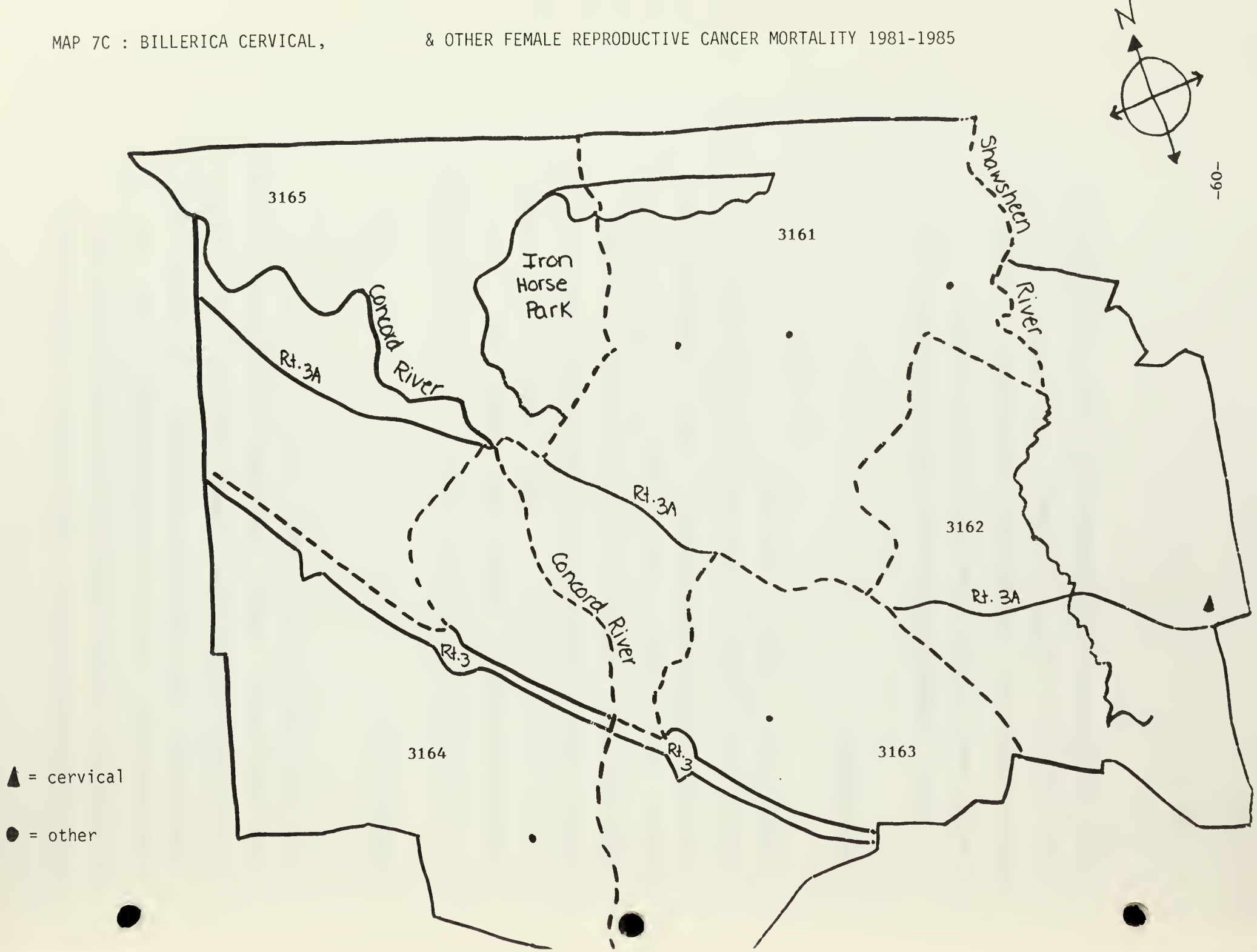
MAP 7A : BILLERICA CERVICAL, & OTHER FEMALE REPRODUCTIVE CANCER MORTALITY 1969-1974



MAP 7 B : BILLERICA CERVICAL, & OTHER FEMALE REPRODUCTIVE CANCER MORTALITY 1975-1980



MAP 7C : BILLERICA CERVICAL, & OTHER FEMALE REPRODUCTIVE CANCER MORTALITY 1981-1985



consistently somewhat elevated. This may be due to a mapping problem encountered with one death during the first time period investigated. Since one decedent could not be assigned to the proper census tract it was counted in each likely census tract of residence; i.e.: into each census tract where the particular street address occurred, in order to present a "worst case" scenario. Overall, deaths appear to have been fairly evenly distributed throughout the town (table 9, figure 8, map series 7).

Prostate Cancer:

Prostate cancer mortality occurred less often than expected for the 17 years analyzed both on a townwide basis and with regard to the individual census tracts (table 1). When each year-group is considered separately there are some elevations in prostate cancer mortality on the census tract level, however the overall trend for each census tract appears to indicate natural flucuation in mortality. That is, if in one time period prostate cancer mortality in a particular census tract was elevated, during the next time period fewer deaths were observed than expected (table 10, figure 9, map series 8).

Bladder Cancer:

Overall, combined male and female bladder cancer mortality was elevated townwide for the 17 year study period (19 observed, 14.5 expected; SMR = 131). This elevation is attributable to an elevation in male bladder cancer mortality (15 observed, 9.9 expected; SMR = 152), as female bladder cancer deaths occurred slightly less often than expected

Table 9

Standardized Mortality Ratios
Other Female Organs
Billerica, MA

	1969-1974	1975-1980	1981-1985
	Female	Female	Female
Town	9/8.4=107	5/8.9=56	5/7.7=65
3161	2/2.4=85*	0/2.6=0	3/2.3=133
3162	4/1.9=208	1/1.9=54	0/1.5=0
3163	2/1.0=205*	0/1.3=0	1/1.2=80
3164	2/1.1=191*	2/1.0=199	1/0.8=122
3165	1/2.1=47	2/2.2=90	0/1.9=0

* = 1 had to be added to each likely census tract of residence due to trouble locating precise address

Note: All values rounded and presented as Observed number/Expected number x 100= Standardized Mortality Ratio

+ or - indicates statistical significance at the 0.05 level
++ or - - indicates statistical significance at the 0.01 level

Statistical significance not calculated where number of deaths is < 5.

Figure 8

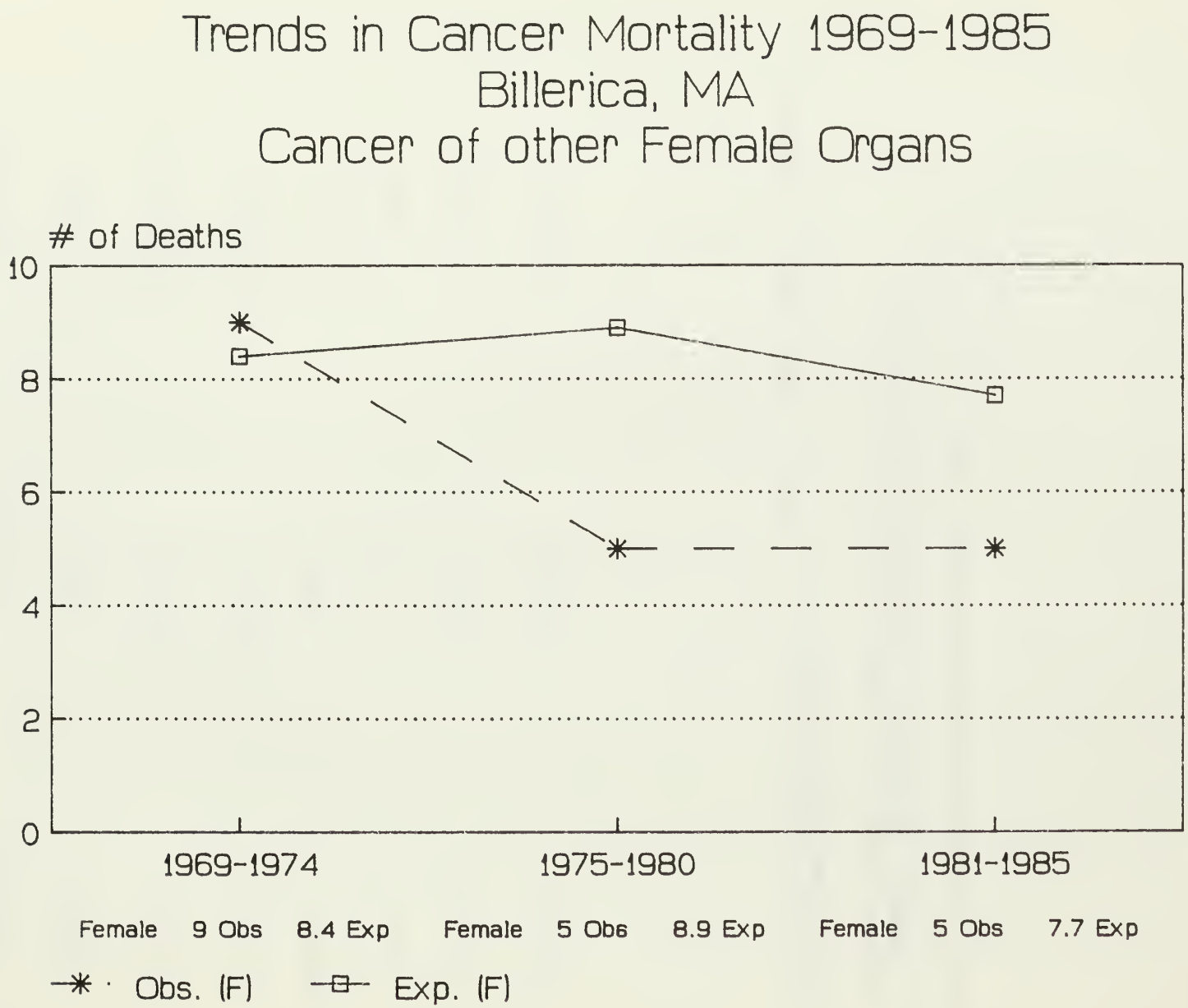

Trends in Cancer Mortality 1969-1985
Billerica, MA
Cancer of other Female Organs
# of Deaths
10
8
6
4
2
0
1969-1974
1975-1980
1981-1985
Female 9 Obs 8.4 Exp
Female 5 Obs 8.9 Exp
Female 5 Obs 7.7 Exp
Obs. (F)
Exp. (F)

Table 10

Standardized Mortality Ratios
Prostate Cancer
Billerica, MA

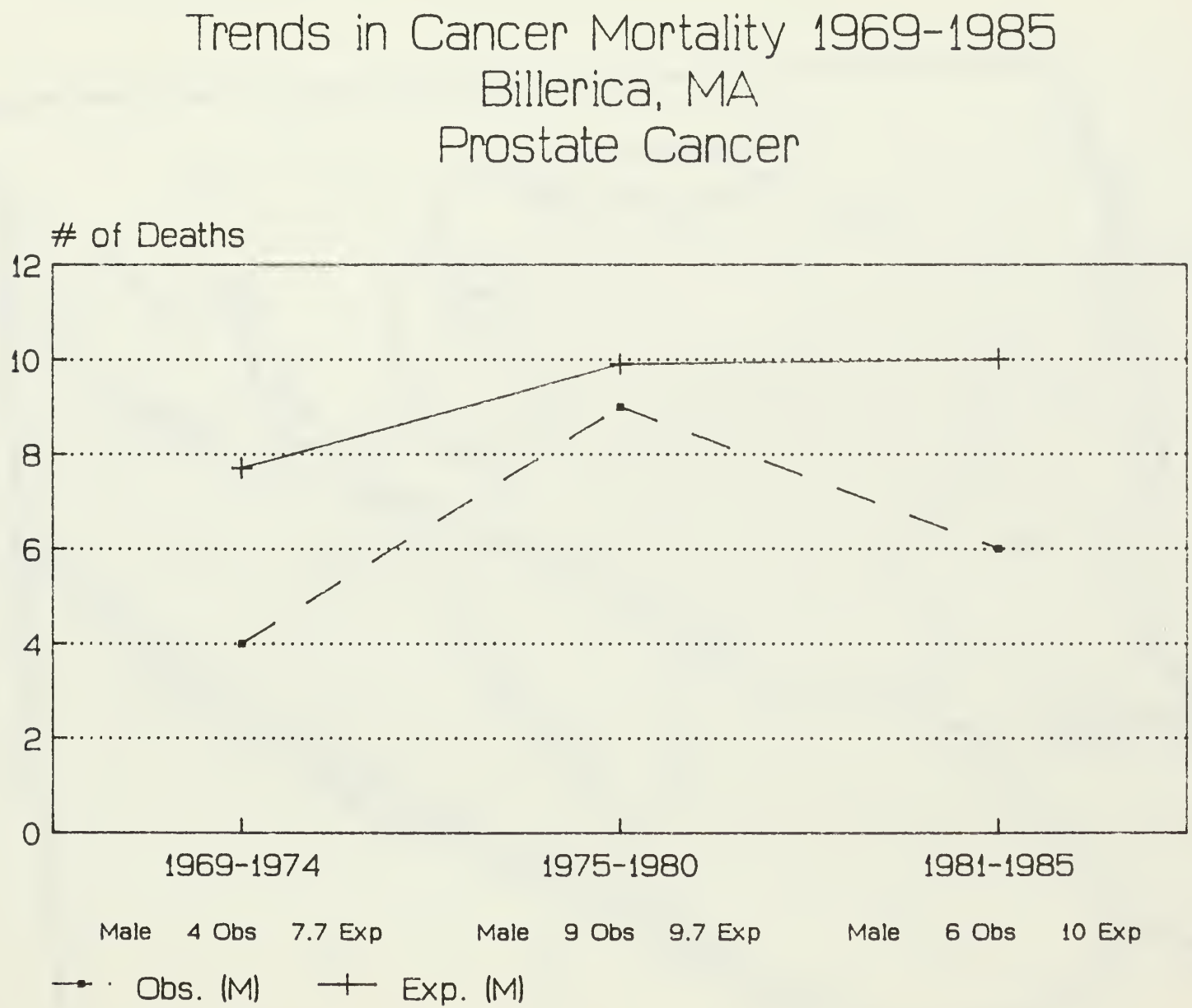
	1969-1974	1975-1980	1981-1985
	Male	Male	Male
Town	4/7.7=51	9/9.7=93	6/10.0=60
3161	1/1.8=55	3/2.3=133	2/2.3=86
3162	0/2.0=0	2/2.4=84	0/1.1=0
3163	1/1.0=99	2/1.4=138	1/1.7=59
3164	1/0.9=107	0/1.2=0	2/1.0=198
3165	1/2.0=50	2/2.5=79	1/2.7=37

Note: All values rounded and presented as Observed number/Expected number x 100= Standardized Mortality Ratio

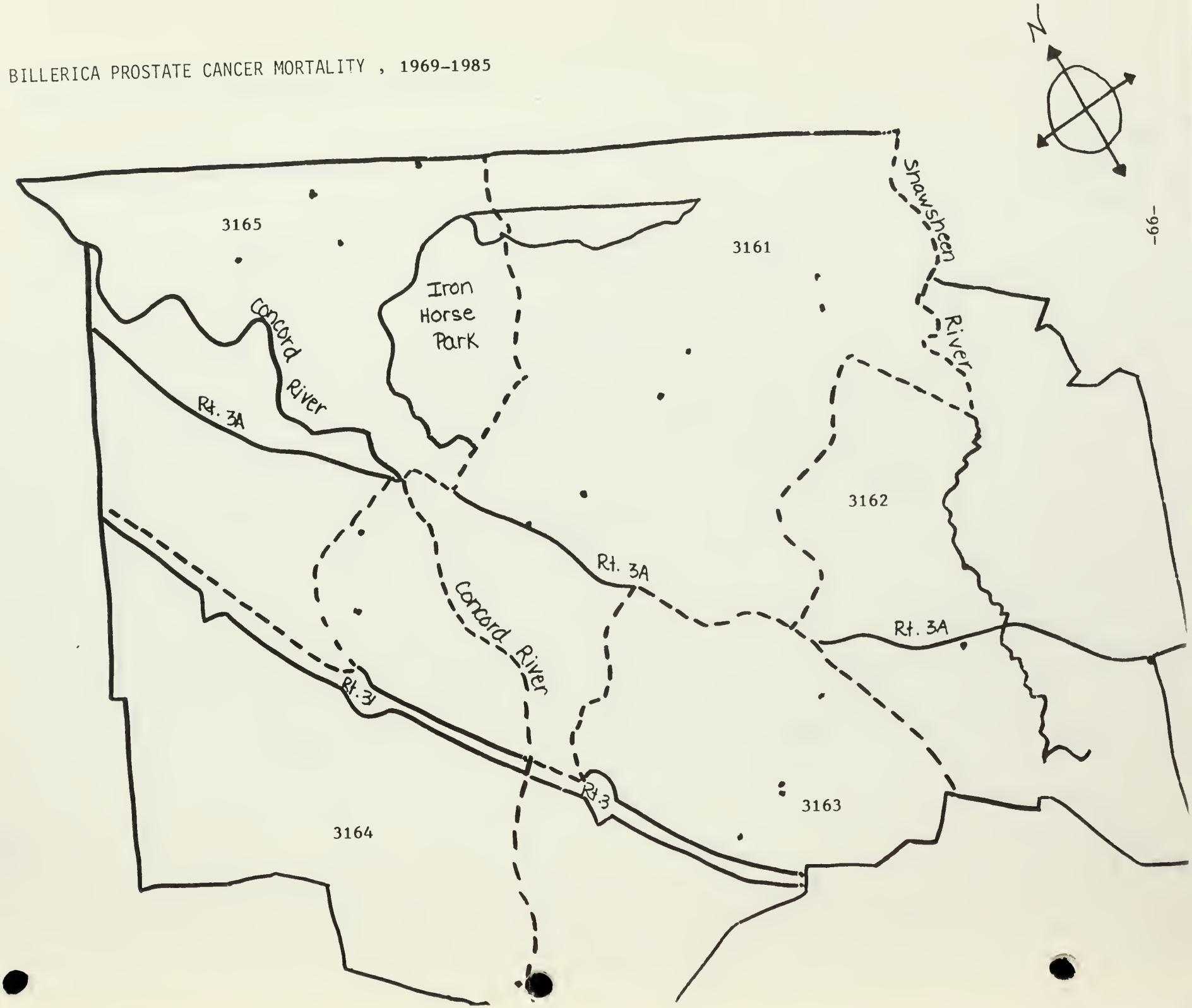
+ or - indicates statistical significance at the 0.05 level
++ or - - indicates statistical significance at the 0.01 level

Statistical significance not calculated where number of deaths is < 5.

Figure 10

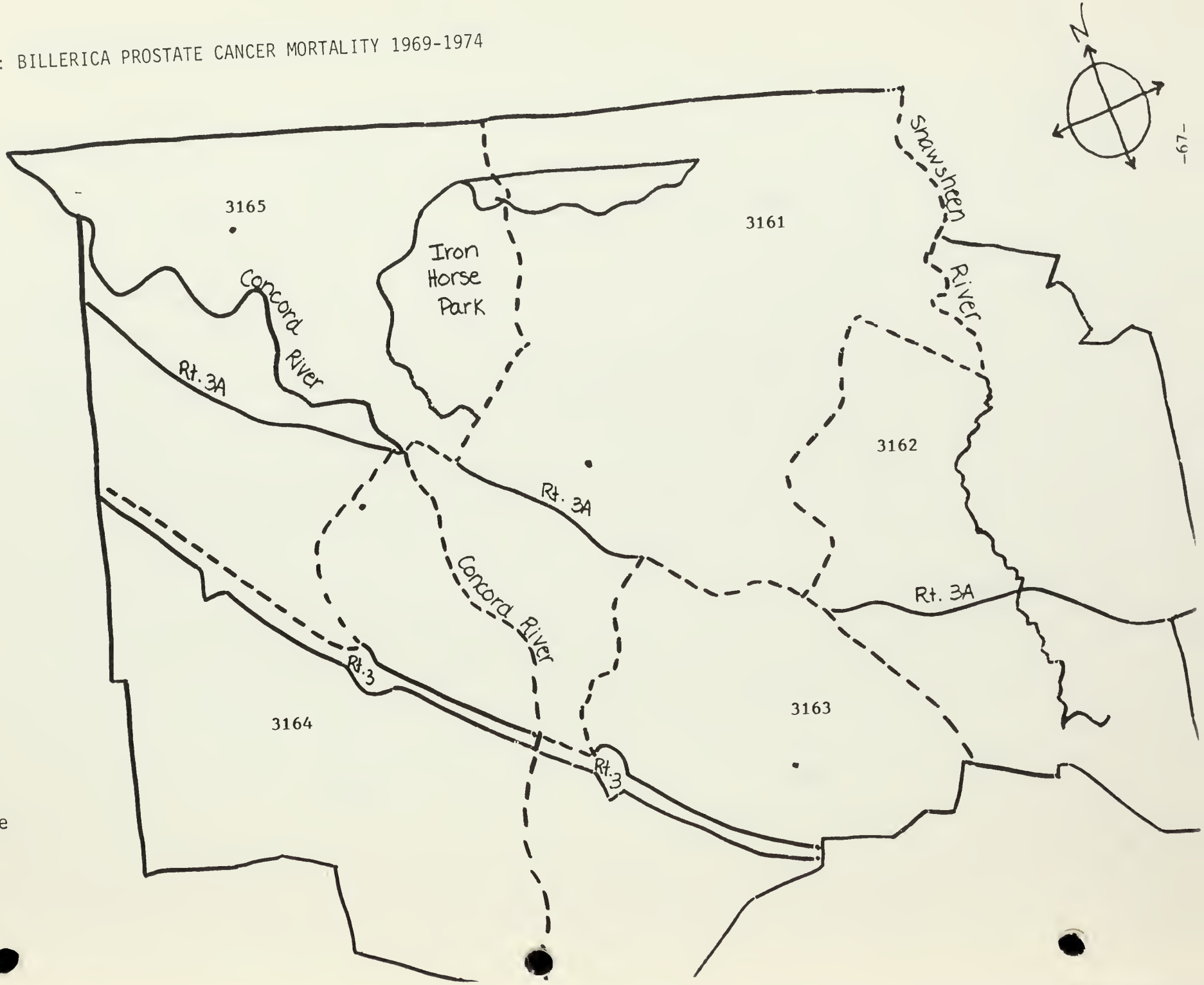

Trends in Cancer Mortality 1969-1985
Billerica, MA
Prostate Cancer
# of Deaths
12
10
8
6
4
2
0
1969-1974
1975-1980
1981-1985
Male 4 Obs 7.7 Exp
Male 9 Obs 9.7 Exp
Male 6 Obs 10 Exp
Obs. (M)
Exp. (M)

MAP 8: BILLERICA PROSTATE CANCER MORTALITY , 1969-1985

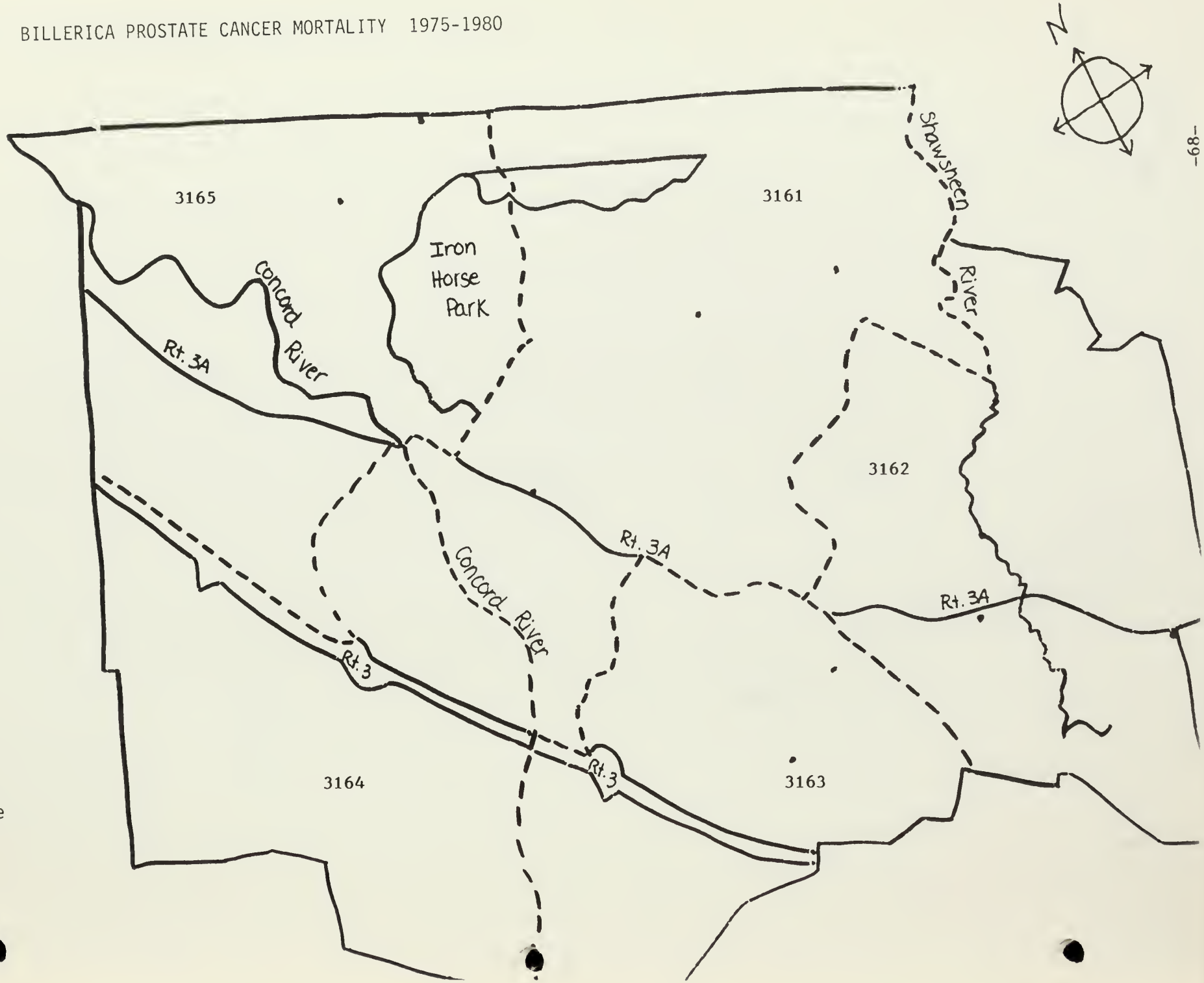


● = male

MAP 8A : BILLERICA PROSTATE CANCER MORTALITY 1969-1974

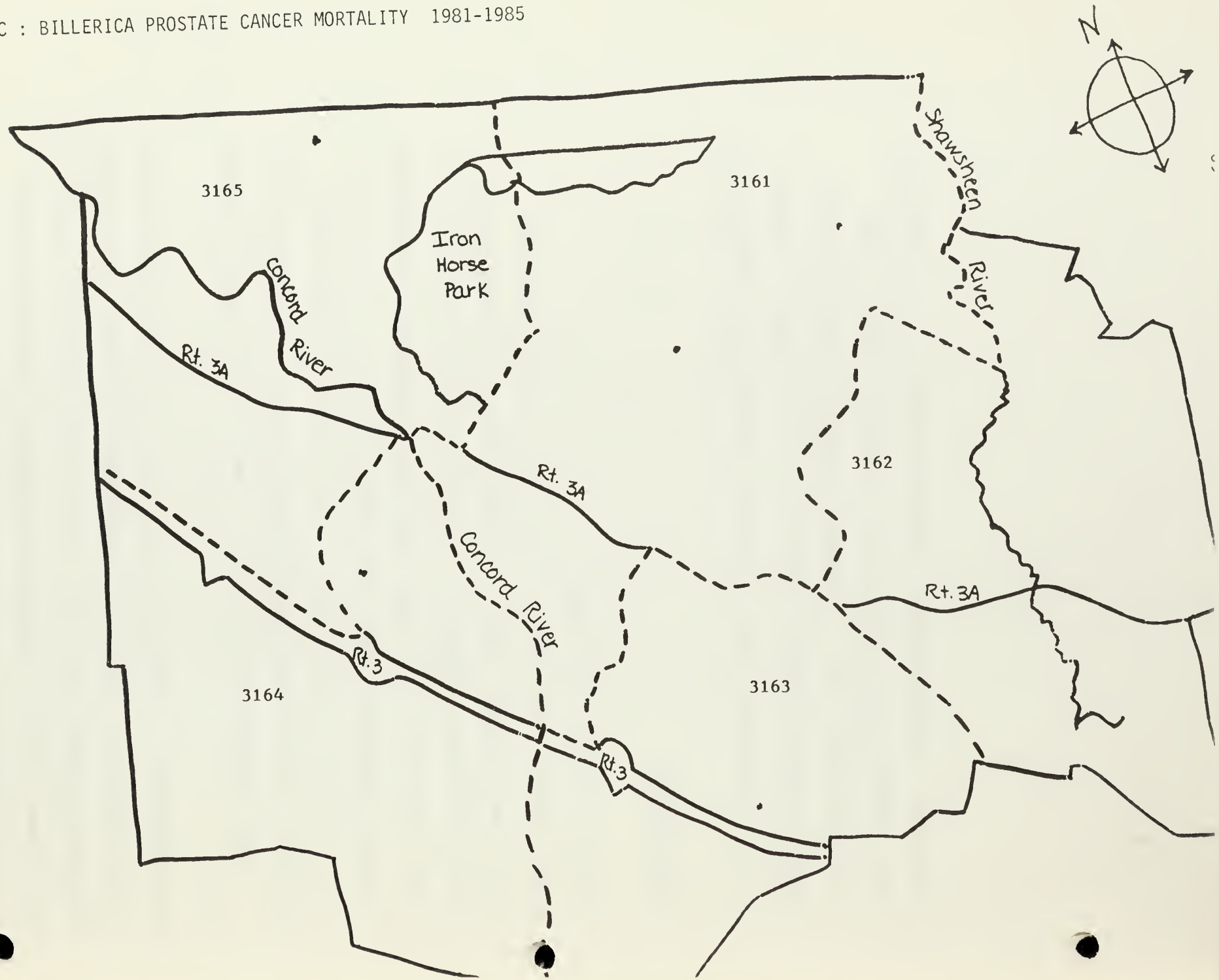


MAP 8B : BILLERICA PROSTATE CANCER MORTALITY 1975-1980



● = male

MAP 8C : BILLERICA PROSTATE CANCER MORTALITY 1981-1985



● = male

over the 17 year period. When individual census tracts were reviewed for the 17 years analyzed, elevations were observed in male bladder cancer mortality in census tracts 3162, 3163, and 3165. The increase observed in census tract 3165 is statistically significant ($p < 0.01$). Female bladder cancer mortality was elevated in census tracts 3162, 3163, and 3164 (table 1).

When considering the time intervals separately the elevation observed in overall (townwide) male bladder cancer mortality is consistent for each of the intervals examined. That is: in no interval was there a major elevation observed that would account for the overall elevation in male bladder cancer mortality. Fewer bladder cancer deaths than expected were observed townwide in females for both the period from 1969-1974 and the period from 1975-1980. There was a slight elevation in female bladder cancer mortality during the last time interval examined (1981-1985). (table 11, figure 10, map series 9)

Kidney Cancer:

Overall, deaths due to cancer of the kidney occurred more frequently than expected based on statewide kidney cancer mortality rates (17 observed, 12.5 expected; SMR = 136). Considered separately, male kidney cancer deaths occurred essentially as often as expected over the 17 years investigated. Females, however, experienced a statistically significant

Table 11

Standardized Mortality Ratios
Bladder Cancer
Billerica, MA

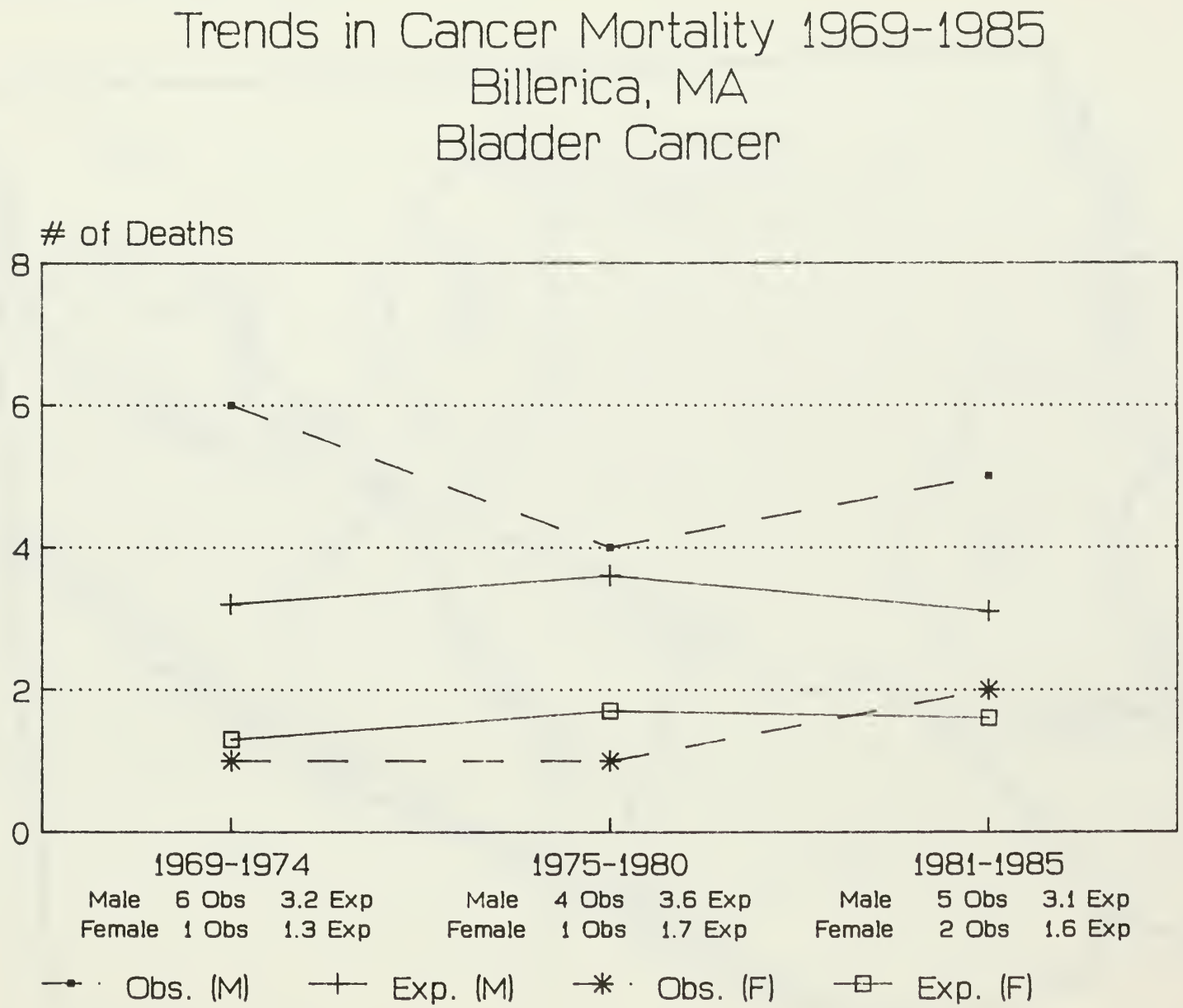
	1969-1974		1975-1980		1981-1985	
	Male	Female	Male	Female	Male	Female
Town	6/3.2=185	1/1.3=79	4/3.6=110	1/1.7=59	5/3.1=160	2/1.6=126
3161	0/0.8=0	0/0.4=0	1/0.9=115	0/0.5=0	0/0.8=0	1/0.5=209
3162	3/0.8=358	0/0.3=0	0/0.9=0	2/0.3=316	0/0.7=0	0/0.3=0
3163	1/0.4=236	1/0.1=727	1/0.5=182	0/0.2=0	1/0.5=190	0/0.2=0
3164	0/0.4=0	0/0.1=0	1/0.5=212	0/0.2=0	0/0.3=0	1/0.1=779
3165	2/0.8=249	0/0.2=0	1/0.9=110	0/0.5=0	4/0.8=506	1/0.5=0

Note: All values rounded and presented as Observed number/Expected number x 100= Standardized Mortality Ratio

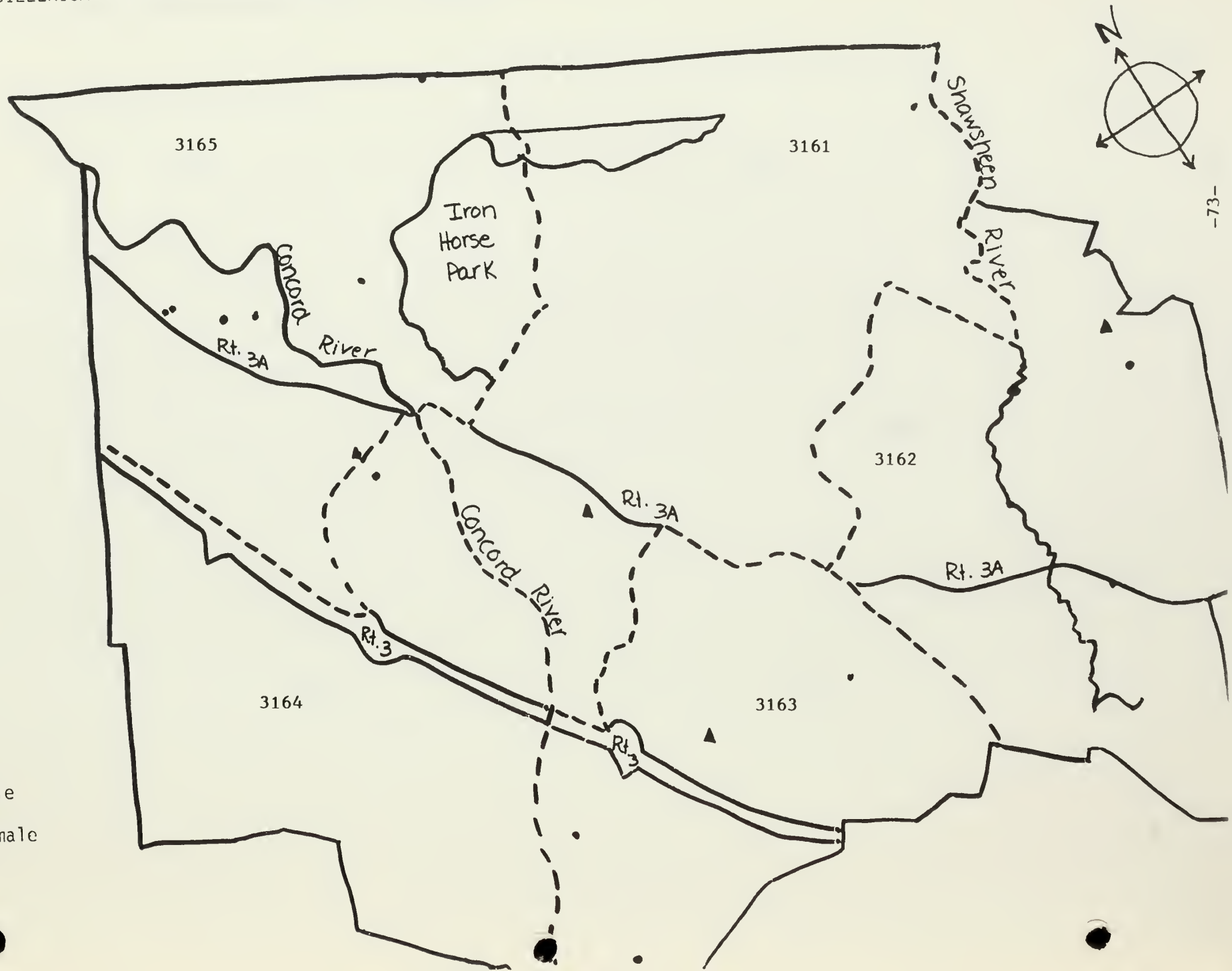
+ or - indicates statistical significance at the 0.05 level
++ or - - indicates statistical significance at the 0.01 level

Statistical significance not calculated where number of deaths is < 5.

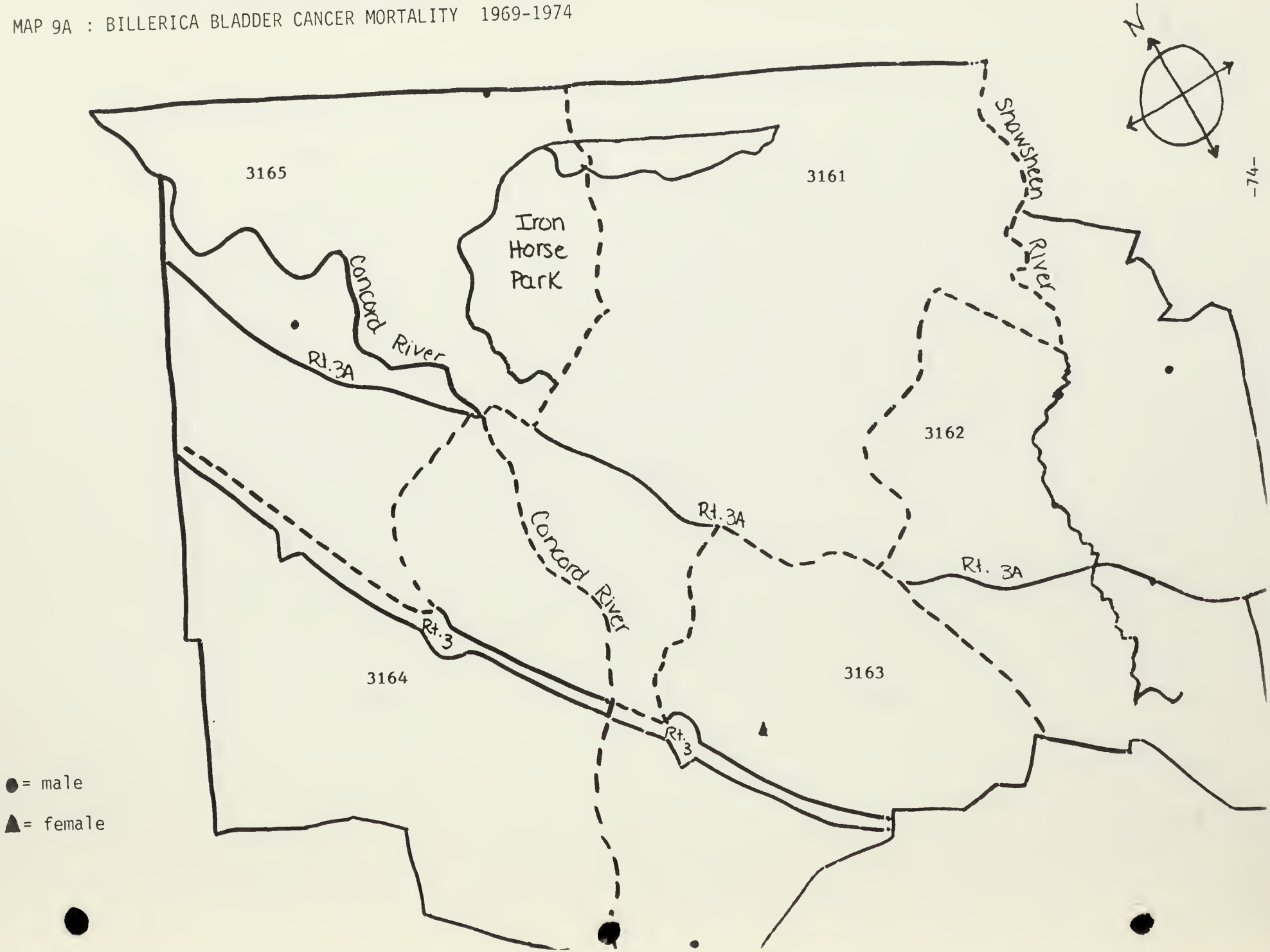
Figure 10


Trends in Cancer Mortality 1969-1985
Billerica, MA
Bladder Cancer
# of Deaths
8
6
4
2
0
1969-1974
Male 6 Obs 3.2 Exp
Female 1 Obs 1.3 Exp
1975-1980
Male 4 Obs 3.6 Exp
Female 1 Obs 1.7 Exp
1981-1985
Male 5 Obs 3.1 Exp
Female 2 Obs 1.6 Exp
Obs. (M)
Exp. (M)
Obs. (F)
Exp. (F)

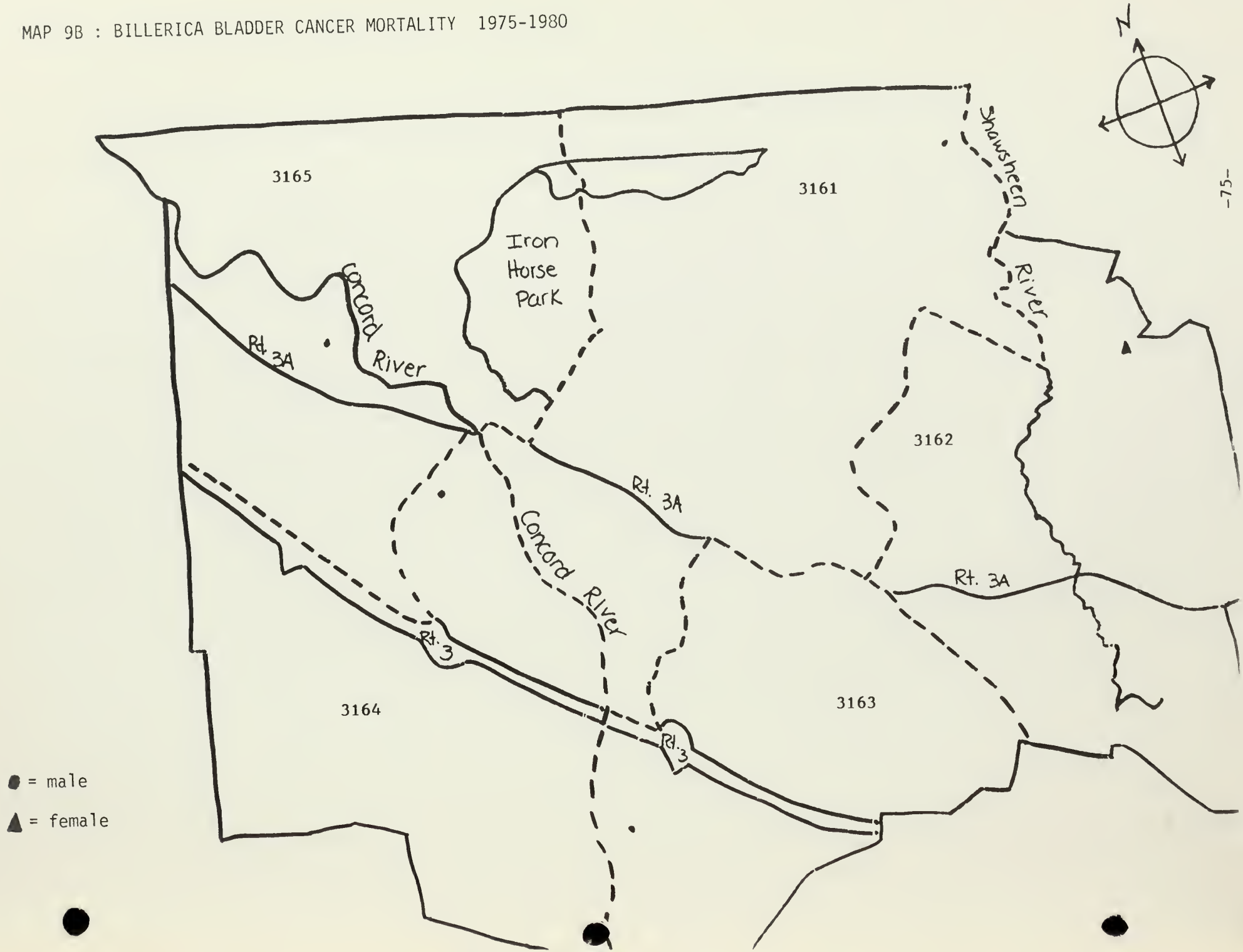
MAP 9 : BILLERICA BLADDER CANCER MORTALITY , 1969-1985



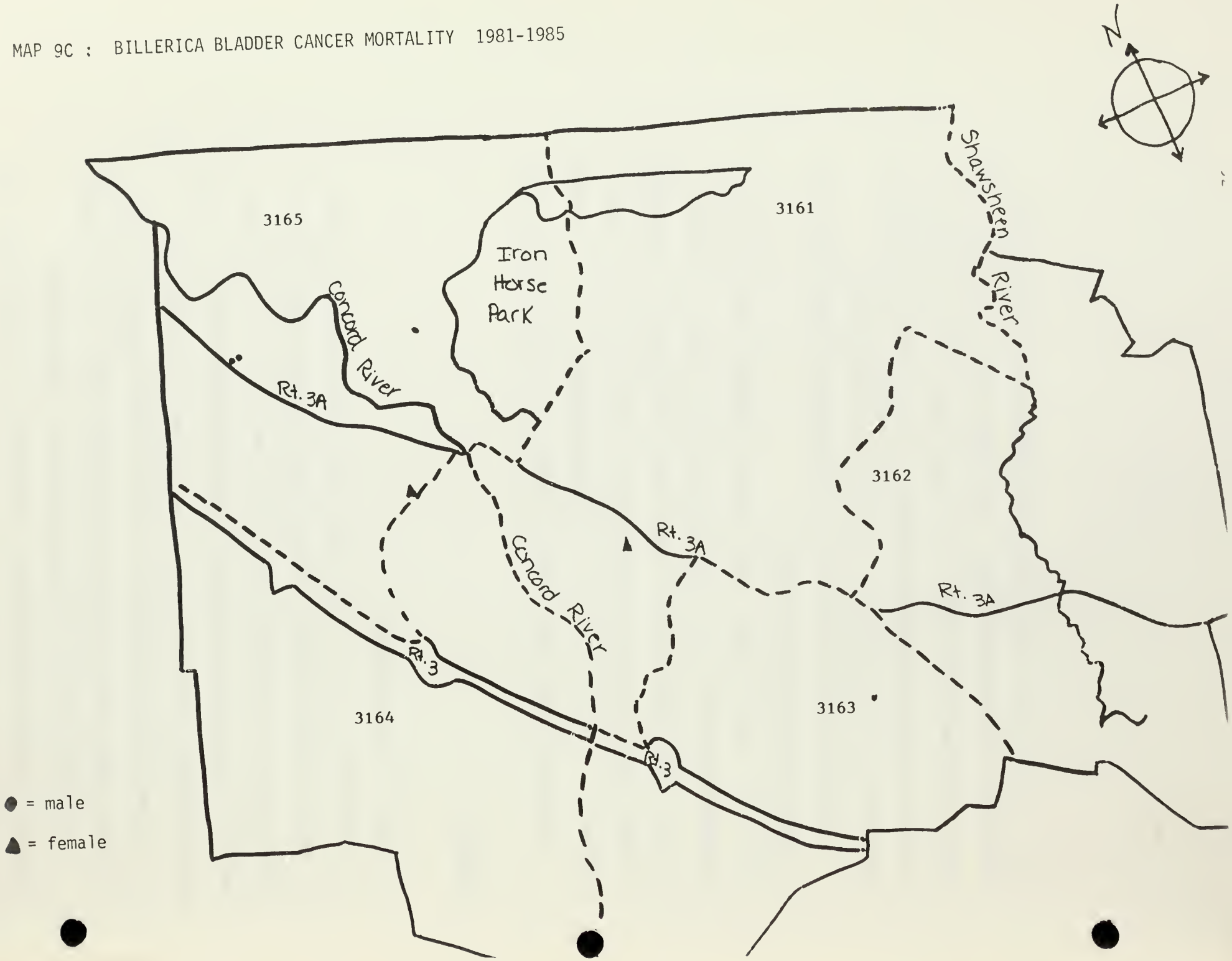
MAP 9A : BILLERICA BLADDER CANCER MORTALITY 1969-1974



MAP 9B : BILLERICA BLADDER CANCER MORTALITY 1975-1980



MAP 9C : BILLERICA BLADDER CANCER MORTALITY 1981-1985



elevation in kidney cancer mortality (9 observed, 4.6 expected; SMR = 196, $p < 0.05$) during this same time period (table 1). With regard to individual census tracts for the same time period, when males and females are combined in census tract 3161,(to achieve greater stability in the numbers), there is an excess number of deaths that is of borderline statistical significance (7 observed, 3.4 expected; SMR = 206, $p = 0.051$). Though there are elevations in other census tracts (3162, 3163 and 3165), the number of deaths was small and therefore statistical significance was not calculated (table 1). Kidney cancer mortality is presented in table 12, figure 11 and map series 11.

Leukemia:

Combined male and female leukemia mortality was somewhat higher than expected for 1969-1985 (31 observed, 26.1 expected; SMR = 119). An excess in female leukemia mortality accounts for the overall elevation (table 1). Over the 17 year period several census tracts have elevations in both male and female mortality. Male leukemia mortality was elevated in census tracts 3161, 3163, and 3165. Female leukemia mortality was elevated in all census tracts except 3165 (table 1).

During the 1969-1974 time period male leukemia deaths occurred with essentially the same frequency as expected on a townwide basis. Elevations in male mortality were observed in census tracts 3163 and 3165. Females experienced more leukemia deaths than would have been expected townwide for this same time period. Elevations occurred in census tracts 3161, 3164, and 3165. From 1975-1980 both males and females had fewer

Table 12

Standardized Mortality Ratios
Kidney Cancer
Billerica, MA

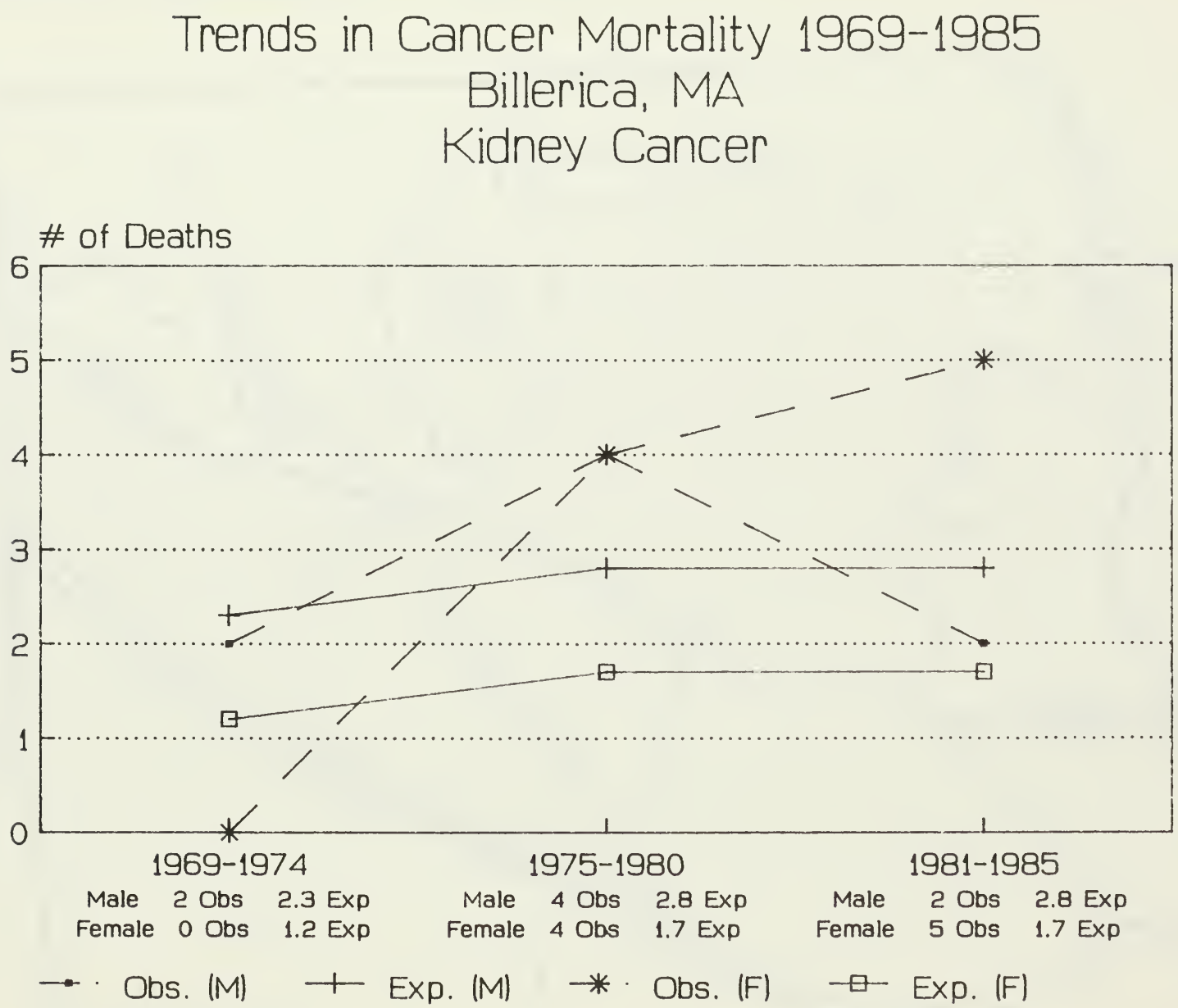
	1969-1974		1975-1980		1981-1985	
	Male	Female	Male	Female	Male	Female
Town	2/2.3=89	0/1.2=0	4/2.8=145	4/1.7=239	2/2.8=72	5/1.7=302+
3161	0/0.5=0	0/0.3=0	3/0.7=431	2/0.5=417	0/0.7=0	2/0.7=276
3162	1/0.6=175	0/0.3=0	0/0.7=0	2/0.3=572	0/0.6=0	1/0.5=197
3163	0/0.3=0	0/0.1=0	0/0.4=0	0/0.2=0	1/0.5=209	1/0.4=242
3164	1/0.3=315	0/0.2=0	0/0.4=0	0/0.2=0	0/0.4=0	0/0.3=0
3165	0/0.5=0	0/0.2=0	1/0.6=160	0/0.4=0	1/0.6=162	1/0.6=167

Note: All values rounded and presented as Observed number/Expected number x 100= Standardized Mortality Ratio

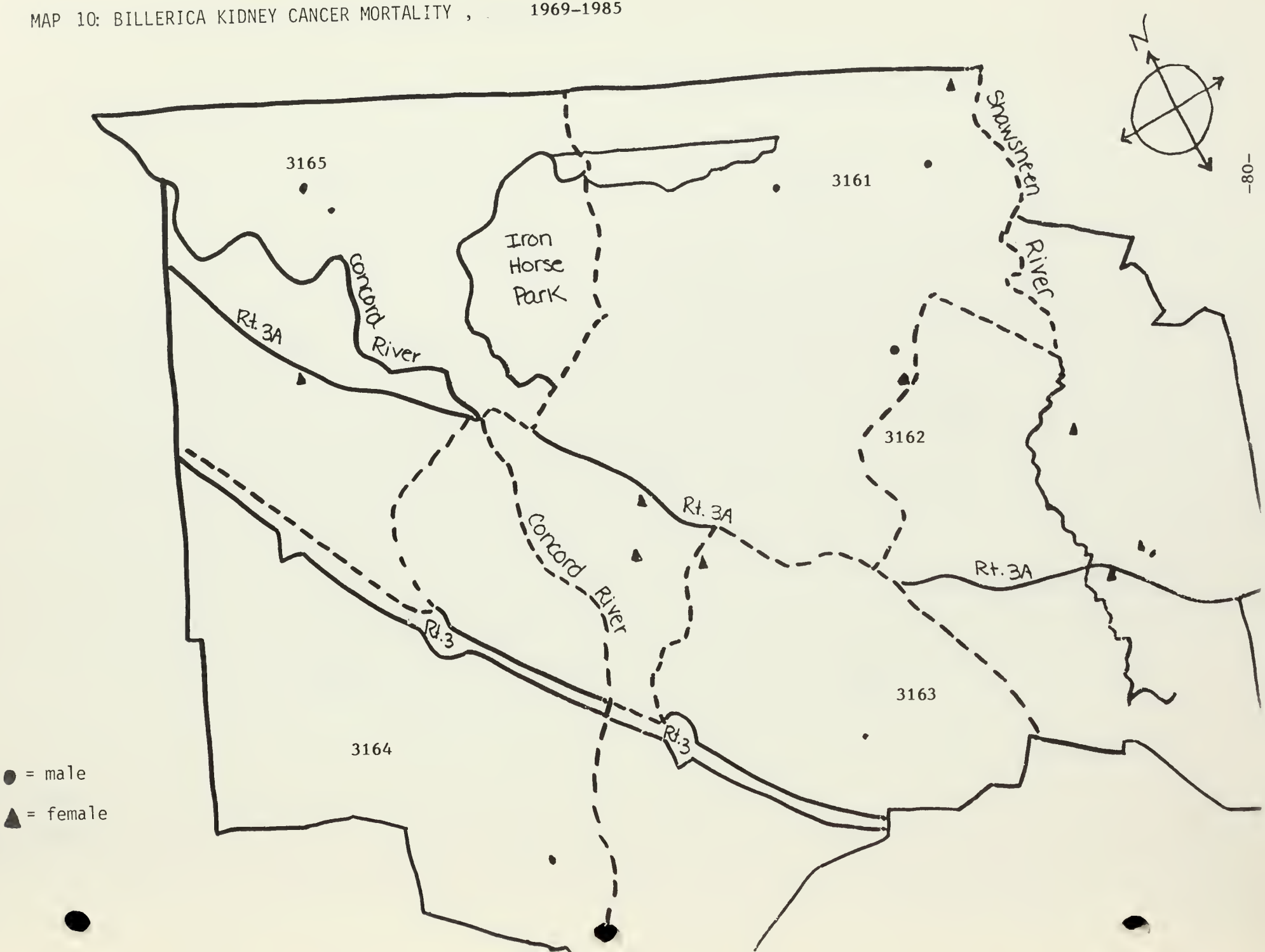
+ or - indicates statistical significance at the 0.05 level
++ or - - indicates statistical significance at the 0.01 level

Statistical significance not calculated where number of deaths is < 5.

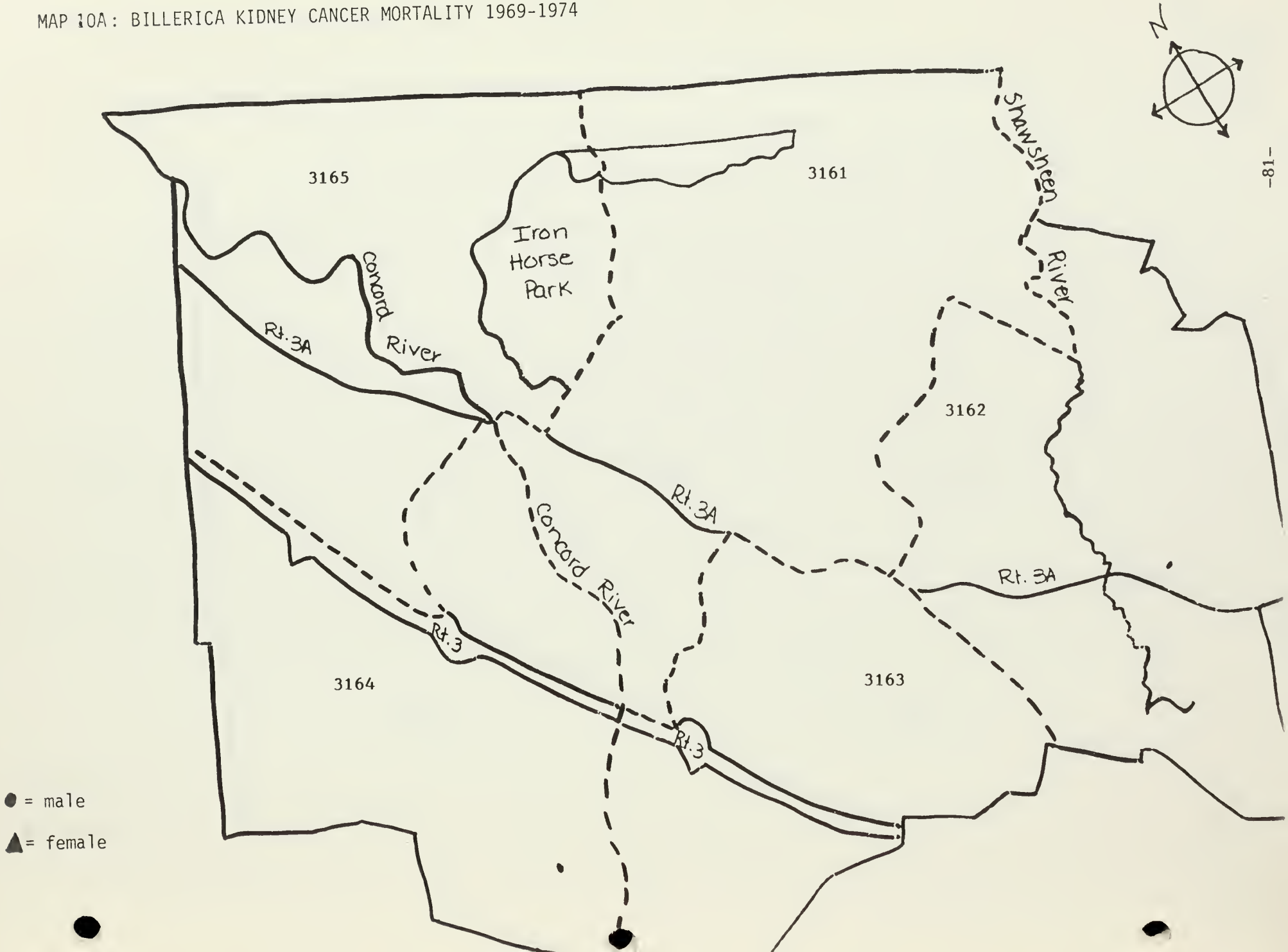
Figure 11


Trends in Cancer Mortality 1969-1985
Billerica, MA
Kidney Cancer
# of Deaths
6
5
4
3
2
1
0
1969-1974
Male 2 Obs 2.3 Exp
Female 0 Obs 1.2 Exp
1975-1980
Male 4 Obs 2.8 Exp
Female 4 Obs 1.7 Exp
1981-1985
Male 2 Obs 2.8 Exp
Female 5 Obs 1.7 Exp
Obs. (M)
Exp. (M)
Obs. (F)
Exp. (F)

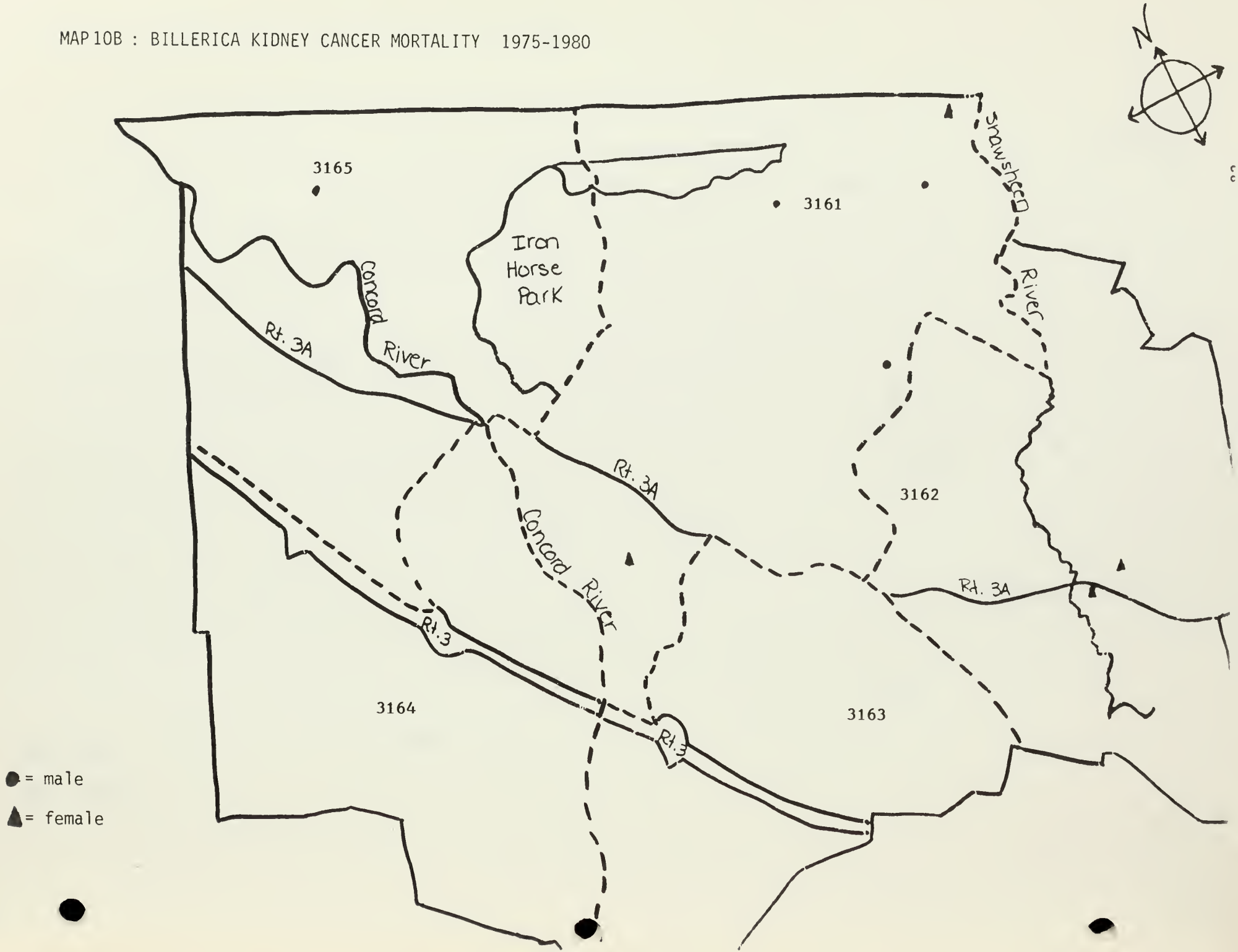
MAP 10: BILLERICA KIDNEY CANCER MORTALITY , 1969-1985



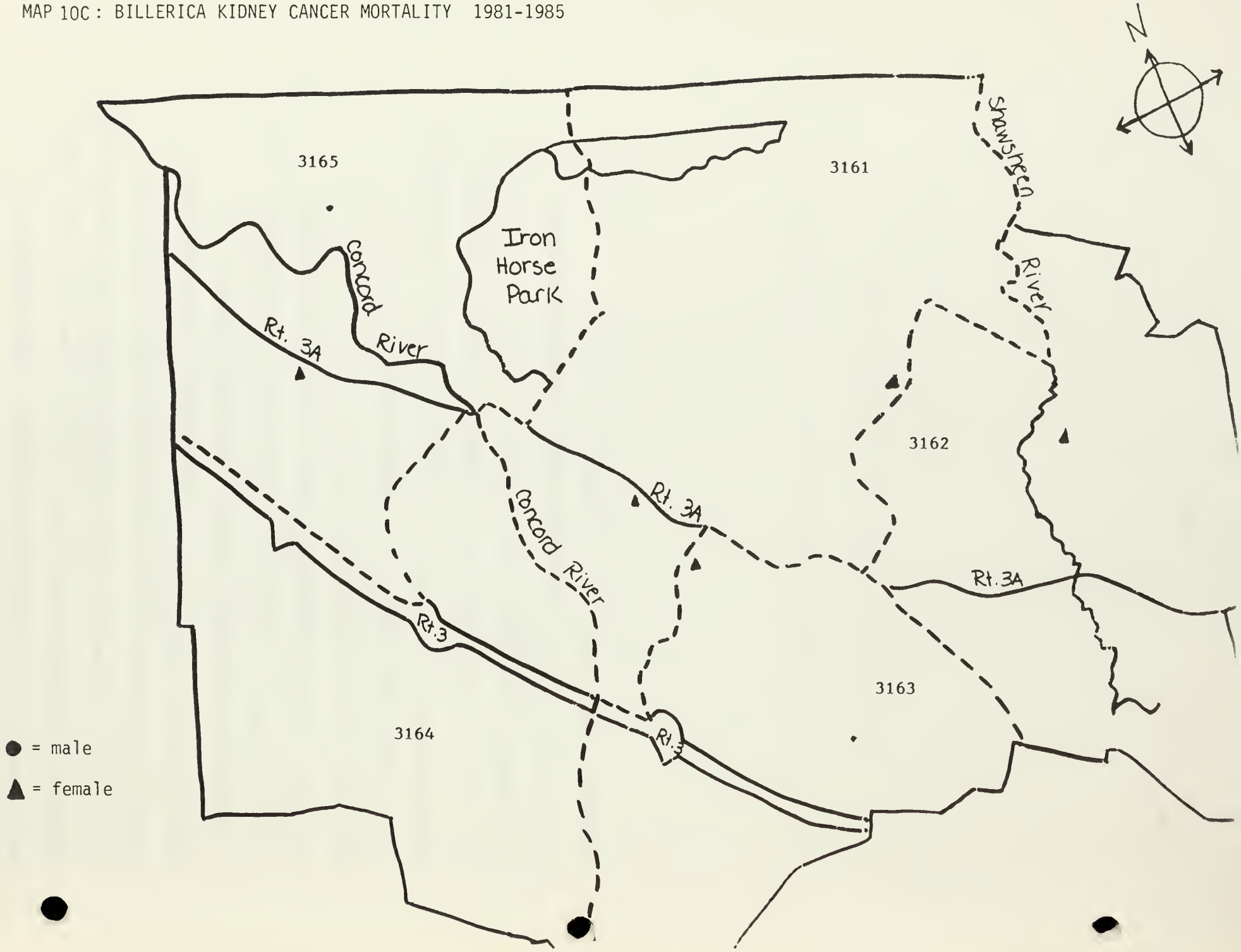
MAP 10A: BILLERICA KIDNEY CANCER MORTALITY 1969-1974



MAP 10B : BILLERICA KIDNEY CANCER MORTALITY 1975-1980



MAP 10C : BILLERICA KIDNEY CANCER MORTALITY 1981-1985



leukemia deaths than expected though there were slight elevations in mortality in particular census tracts. For males these were census tracts 3163 and 3164. For females elevations were observed in census tracts 3162 and 3163. Both male and female leukemia mortality was elevated for the last time interval. Considered separately neither of these elevations is of statistically significant. However, the combined number is of borderline statistical significance (14 observed, 8.5 expected; SMR = 165, $p = 0.059$). The most notable elevations in mortality were observed in census tracts 3161 and 3163 (table 13, figure 12, map series 11). If males and females are combined in census tract 3161 the elevation in leukemia mortality is statistically significant (6 observed, 2.4 expected; SMR = 250, $p < 0.05$). As has been the case with several other cancers, when assessing at the census tract level for the particular time periods, in certain census tracts the expected numbers are quite small and, consequently, SMR's should be interpreted accordingly.

Table 13

Standardized Mortality Ratios
Leukemia
Billerica, MA

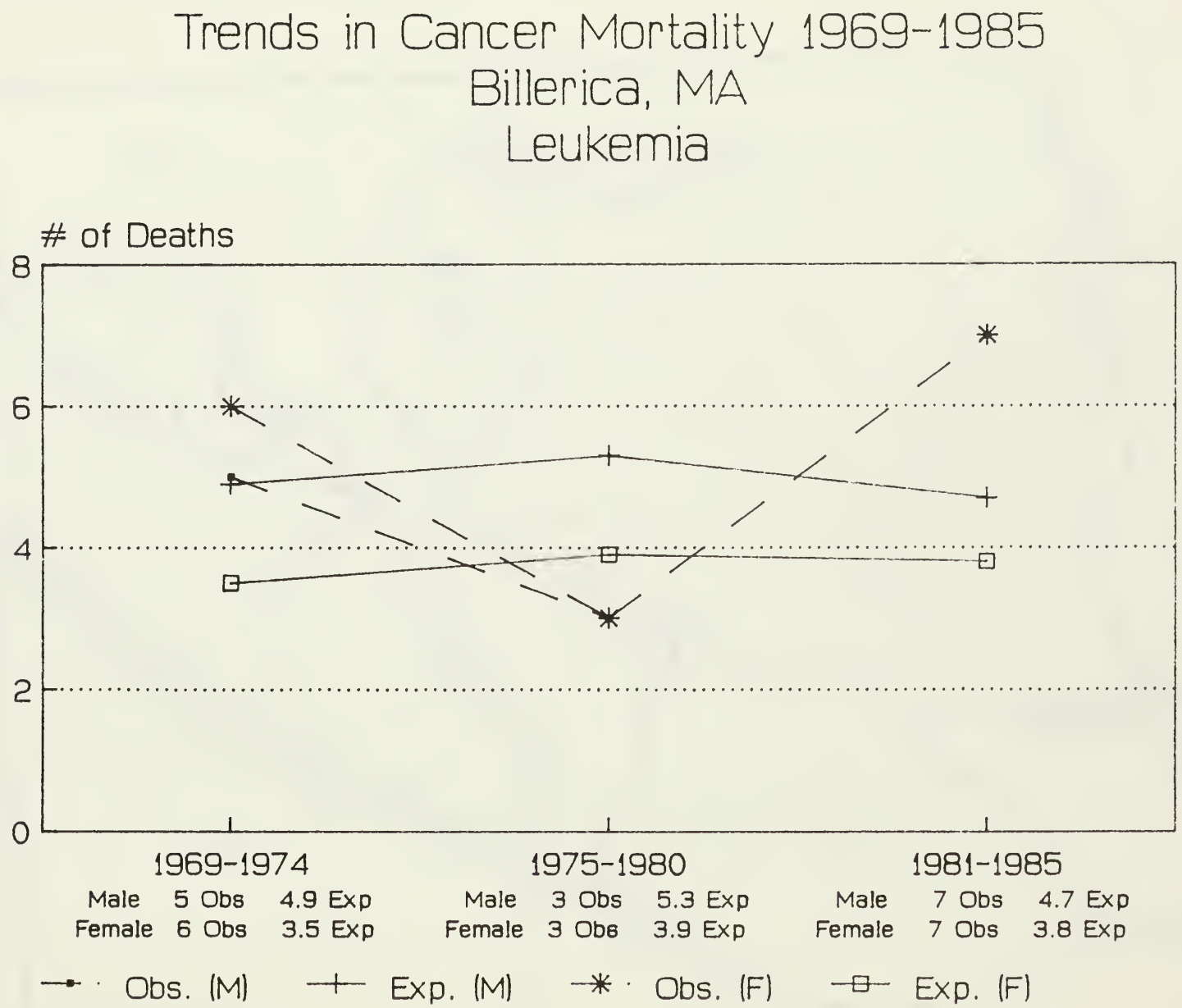
	1969-1974		1975-1980		1981-1985	
	Male	Female	Male	Female	Male	Female
Town	5/4.9=101	6/3.5=170	3/5.3=57	3/3.9=78	7/4.7=149	7/3.8=185
3161	1/1.3=79	3/1.0=291	0/1.4=0	0/1.2=0	4/1.3=318	2/1.1=175
3162	1/1.2=81	0/0.8=0	0/1.2=0	2/0.8=252	0/1.0=0	1/0.7=139
3163	1/0.6=163	0/0.4=0	1/0.8=129	1/0.5=189	1/0.8=129	3/0.6=516
3164	0/0.8=0	2/0.5=415	1/0.8=129	0/0.5=0	1/0.6=163	1/0.4=252
3165	2/1.1=181	1.0.8=122	1/1.2=86	0/0.9=0	1/1.0=99	0/0.9=0

Note: All values rounded and presented as Observed number/Expected number x 100= Standardized Mortality Ratio

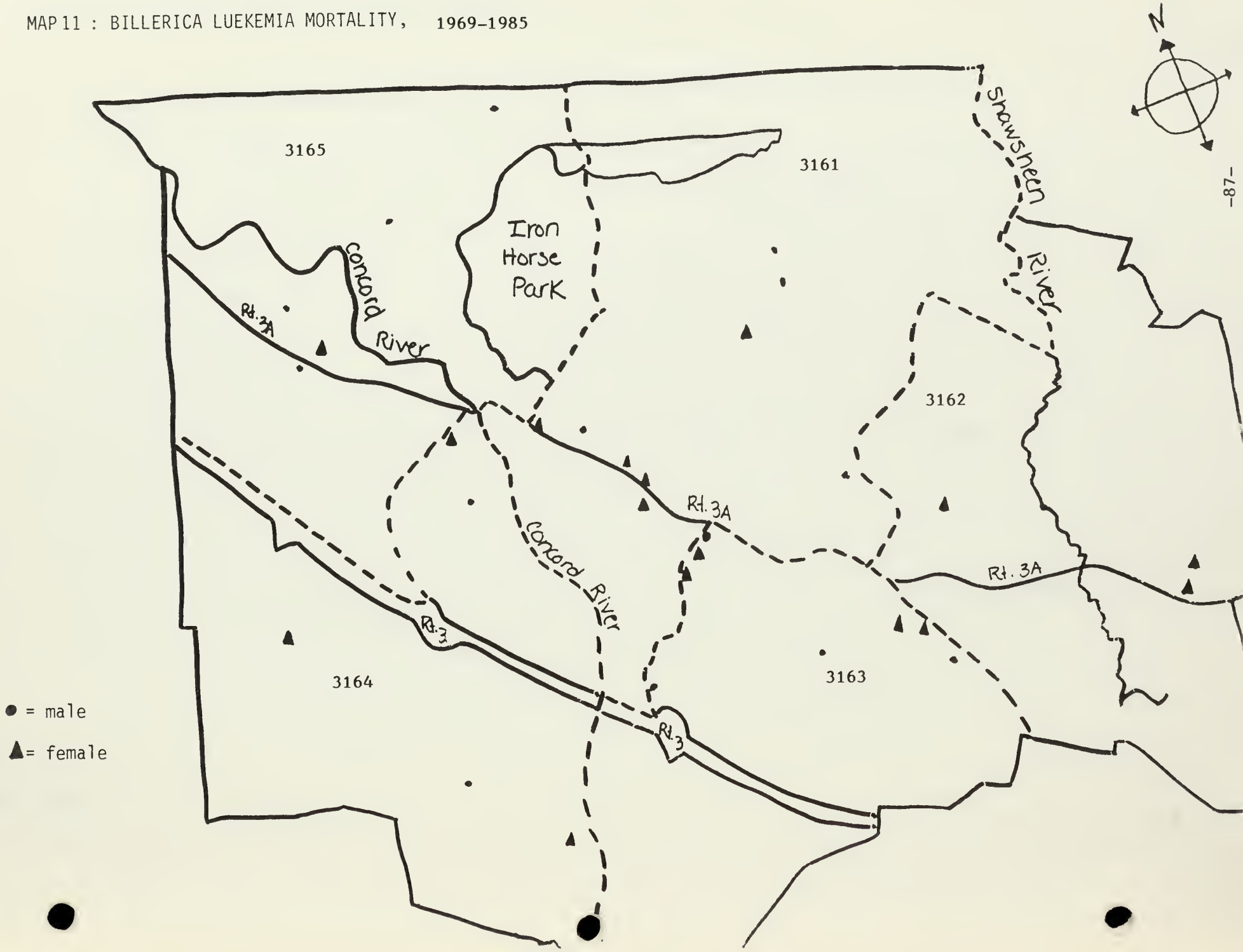
+ or - indicates statistical significance at the 0.05 level
++ or - - indicates statistical significance at the 0.01 level

Statistical significance not calculated where number of deaths is < 5.

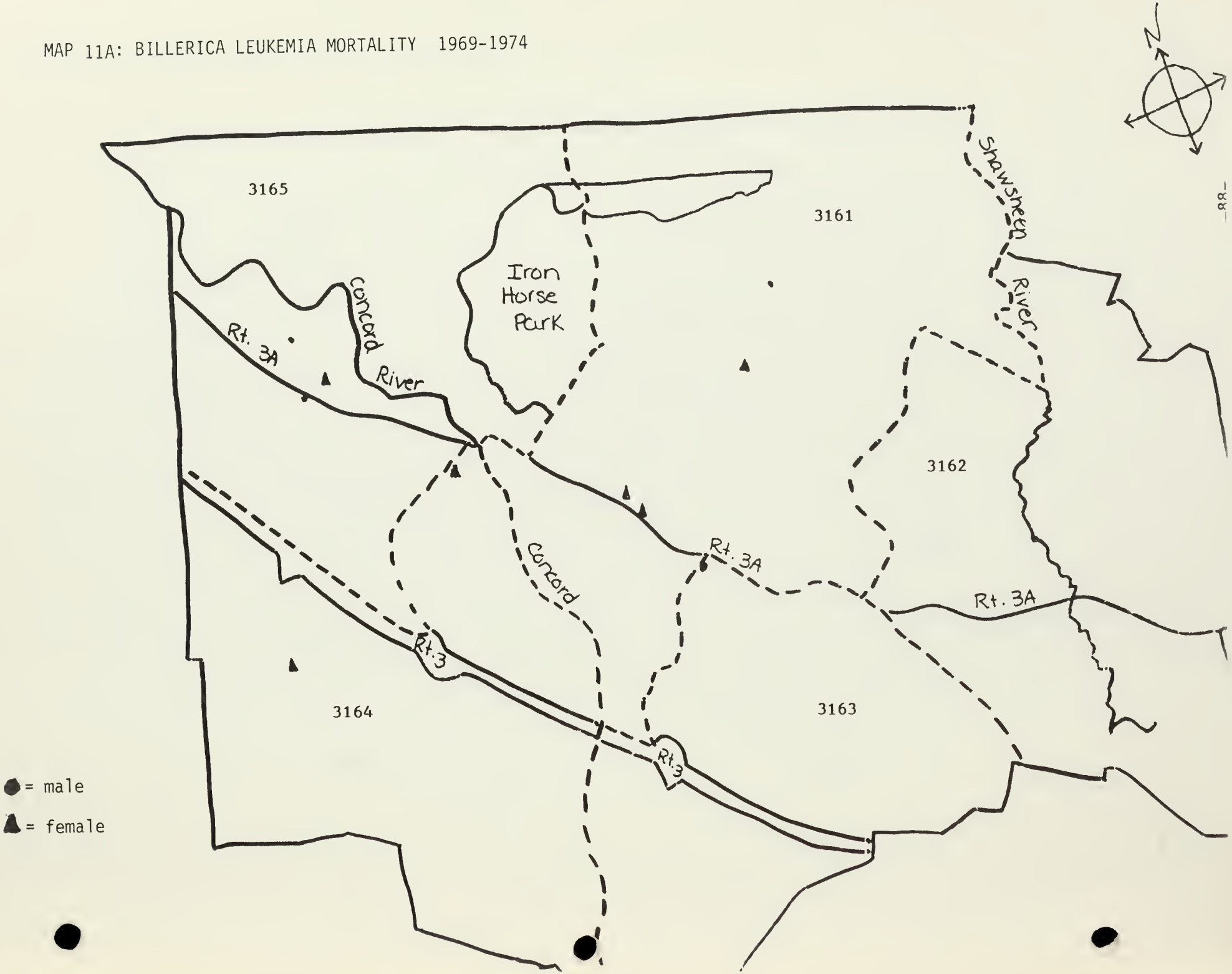
Figure 12


Trends in Cancer Mortality 1969-1985
Billerica, MA
Leukemia
# of Deaths
8
6
4
2
0
1969-1974
Male 5 Obs 4.9 Exp
Female 6 Obs 3.5 Exp
1975-1980
Male 3 Obs 5.3 Exp
Female 3 Obs 3.9 Exp
1981-1985
Male 7 Obs 4.7 Exp
Female 7 Obs 3.8 Exp
Obs. (M)
Exp. (M)
Obs. (F)
Exp. (F)

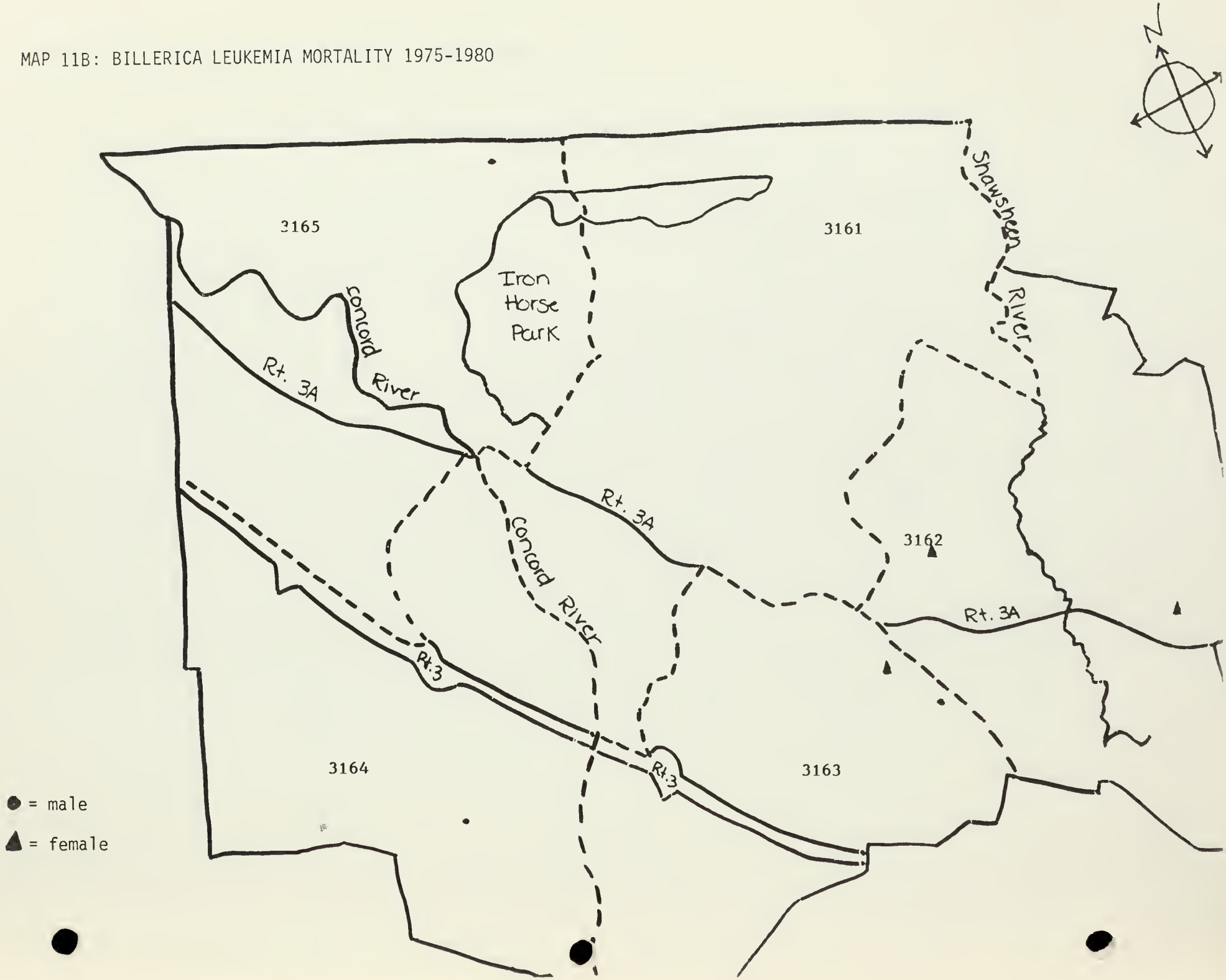
MAP 11 : BILLERICA LUEKEMIA MORTALITY, 1969-1985



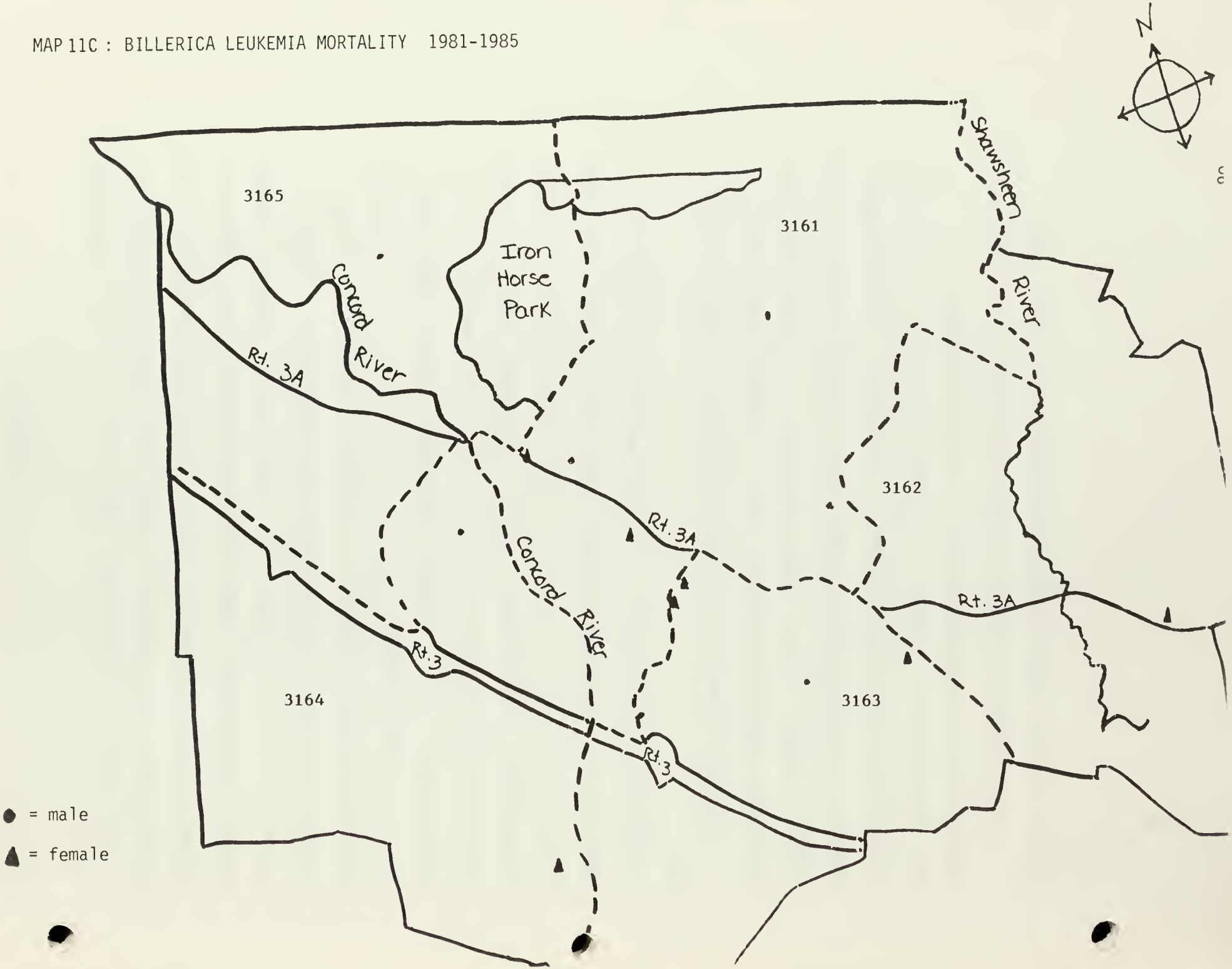
MAP 11A: BILLERICA LEUKEMIA MORTALITY 1969-1974



MAP 11B: BILLERICA LEUKEMIA MORTALITY 1975-1980



MAP 11C : BILLERICA LEUKEMIA MORTALITY 1981-1985



IV. DISCUSSION

In a descriptive epidemiologic study information on cause and effect for individuals is not collected. Instead, only existing data that are routinely collected by the MDPH DHSR (i.e.: death certificates, etc.) are utilized. By themselves, these types of data are not usually considered critical evidence in determining cause and effect with regard to disease mortality, and should be used cautiously in assessing the influence of possible environmental exposures. In addition, information on crucial factors influencing disease incidence and mortality such as occupational history, medical history, lifestyle risk factors, socio-economic status and access to medical care are not accounted for and therefore could not be considered in these analyses. Despite the inherent limitations in the use of descriptive data, by identifying areas where a greater (or fewer) number of cancer deaths have occurred, these types of studies are useful in determining whether further study may be warranted in a particular area.

Different cancers have different associated risk factors. Many cancers are thought to be related largely to lifestyle habits such as cigarette smoking, diet and alcohol consumption. Animal experiments and epidemiologic studies have also linked several cancers to adverse chemical exposures that occur in the workplace or in a person's home environment. Other factors that are believed to influence the incidence of cancer are socioeconomic class, heredity/genetics, race and geography.

The following is a summary of what is known about the incidence and etiology of the 12 types of cancer considered in this report. This

information was compiled from: 1) Cancer Epidemiology and Prevention edited by Schottenfeld and Fraumeni 2) Cancer: A Manual for Practitioners by the American Cancer Society. and 3) Cancer Rates and Risks by the National Institutes of Health.

Stomach Cancer:

Surveys have shown an association between stomach cancer and diets that include large amounts of pickled, smoked or salted foods. More recently, individuals with conditions that affect the stomach lining such as atrophic gastritis and pernicious anemia are at an increased risk of developing stomach cancer. A diet high in fresh fruit and vegetables has been associated with a decreased risk for stomach cancer.

Colo/Rectal Cancers:

Increased risk of colo/rectal cancers has been strongly associated with long term ulcerative colitis, Crohn's disease and familial polyposis. Colo/rectal cancer rates have also been highly correlated with dietary fat intake, and, as with stomach cancer, a diet high in fiber appears to decrease colo/rectal cancer risk. Although it is not usually considered an occupational disease it has been observed at higher than expected frequency in persons who worked with asbestos and in textile workers.

Liver Cancer:

The predominant factors thought to influence the worldwide incidence of primary liver cancers are hepatitus B virus, cirrhosis and aflatoxins. Since alcohol consumption is closely related to cirrhosis, heavy drinking may be a risk factor for liver cancer development, though the relationship between the two diseases is not fully understood. Aflatoxins are produced as a result of poor food handling and storage practices. They are potent carcinogens in laboratory animals. Workplace exposure to vinyl chloride monomer has been highly correlated with angiosarcoma, a rare type of liver cancer. Angiosarcoma has also been noted in workers exposed to inorganic arsenical insecticides. Other factors thought to influence the risk of primary liver cancer are oral contraceptive use and androgenic anabolic steroids.

Pancreatic Cancer:

Cancer of the pancreas has been associated in several studies with cigarette smoking. One study has suggested that persons employed in the dry cleaning business or in gasoline related occupations face an increased risk of developing pancreatic cancer. Some researchers associated risk of developing pancreatic cancer with excessive use of alcohol; however, other investigations have refuted these findings. Diabetes mellitus has been linked with increased incidence of cancer of the pancreas, but it is not known whether the cancer causes diabetes-like changes or if diabetes predisposes an individual to this type of cancer.

Lung Cancer:

Lung cancer represents 15% of all cancer cases nationwide (22% in males and 8% in females). Cigarette smoking is by far the major risk factor for lung cancer. It has been estimated that, in the United States, cigarette smoking contributes to at least 80% of the lung cancers seen in males and 40% of the lung cancers seen in females. There is increasing evidence that passive smoking (i.e.: exposure to someone else's cigarette smoke) may increase an individuals risk of contracting lung cancer.

Some occupational exposures that have been associated with increased lung cancer incidence are: chromium (plating etc.), nickel (smelting, roasting and electrolysis), ionizing radiation (x-ray, gamma ray), radon and radon daughters (uranium mining), inorganic arsenic (sheep-dip manufacture, copper smelting, pesticide/herbicide manufacturing), chloromethyl ethers (manufacture of ion-exchange resins), and asbestos (shipbuilding, textiles, millers, roofers).

Breast Cancer:

Breast cancer is the leading cause of cancer death in American women. There are several factors that may influence individual breast cancer risk. Since breast cancer is the most prevalent in areas with a high socio-economic status, diet has been considered a possible risk factor. Studies have found that women whose mothers had breast cancer are at a risk of 1.5 - 3 times greater for developing breast cancer. In women whose mother and a sister had breast cancer the risk increases six-fold. Early onset of menstruation and late menopause, few or no children or

children later in life also appear to play a role in breast cancer risk.

Cervical Cancer/Other Female Organ Cancers:

Epidemiologic studies indicate that two strong risk factors for cervical cancer are multiple sexual partners and early age at first intercourse. There also may be some association between cervical cancer and cigarette smoking. Decreased incidence of cervical cancer is seen among women who use barrier methods of birth control. Endometrial cancer risk factors resemble those for breast cancer. Cancer of the ovary has been associated with occupational exposure to asbestos and talc. Pregnancy or the use of birth control pills appears to decrease ovarian cancer risk.

Prostate Cancer:

Cancer of the prostate is one of the most common forms of cancer in men. Because international incidence patterns vary considerably, dietary fat intake has been considered a risk factor. It is unclear as to whether this is simply due to diet or that fat intake may effect hormone production. Occupational exposures to cadmium and zinc have been associated with increased prostate cancer mortality.

Bladder Cancer:

As with lung cancer, cigarette smoking is the most important known risk factor for bladder cancer. Research has indicated that cigarette

smokers will develop bladder cancer 2-3 times more often than non-smokers. It is estimated that 40% of bladder cancers in men are due to cigarette smoking.

Occupations in which workers are suspected of having a greater risk of developing bladder cancer include work in the rubber and leather industries, painting, chemical work, printing, metal work, hairdressing, textile work, machine work, and truck driving. Benzidine and 2-naphthylamine, two chemicals that were used in the dyestuffs industry, are known bladder carcinogens.

Kidney Cancer:

Cigarette smoking is also the most well established risk factor for cancer of the kidneys. Elevated kidney cancer rates have been reported among coke oven workers and have been associated with occupational exposure to asbestos. Obesity appears to be a risk factor in women.

Leukemia:

Leukemia represents a group of cancers that arise in the cells of blood and bone marrow. Each type of leukemia is different with regard to etiology, prognosis, and treatment. Some factors which influence the incidence of leukemia are genetic traits such as Downs syndrome, ionizing radiation, and exposure to benzene and, possibly, other solvents used in industry.

Overall, the most striking result of these analyses are the elevations in lung cancer mortality observed among both males and females. Male lung cancer mortality has stayed consistently elevated in

several areas of town. Additionally, several of the statistically significant elevations were in census tracts that border areas of environmental concern. One of the primary contaminants of concern in Billerica is asbestos. Asbestos is a known lung carcinogen, and has been present in the Billerica environment since the 1940's. Through remediation by the EPA the Iron Horse Park asbestos waste site was capped, first in the early 1970's and then again (after the first cap was found to be eroding) in 1984, which eliminated the possibilty of airborne exposure to asbestos.

Although overall female lung cancer mortality rates were elevated the elevation is not consistent through time. There were, however, several notable elevations.

Significant elevations were also noted in kidney cancer mortality for women for the 1969-1985 period. When assessing the individual time periods and the census tracts within these time periods it should be kept in mind that because kidney cancer is such a rare event, expected values are of the magnitude of fractions of a death; consequently, SMR's appear unusually high in census tracts where a kidney cancer death occurred (table 12, figure 11, map series 10). This is not to say that the excess mortality observed is of no importance, only that it should be interpreted with caution. Exposure to asbestos has been positively associated with kidney cancer mortality in a study of insulation workers (Selikoff, Hammond, and Seidman. (1979) Mortality Experience of Insulation Workers in the U.S. and Canada 1943-1976. Annals N.Y. Acad Sci. 330:91-116). The elevation in male bladder cancer in census tract 3165 for the 17 year period is also noteworthy. Additionally, male bladder cancer deaths do appear to be more prevalent in one area of census tract 3165; however,

there are several possible explanations for this and due to the small number of deaths these findings should be interpreted with caution. Other elevations in cancer mortality also exist in Billerica but the aforementioned elevations in these cancer sites appear the most striking.

Because the lung cancer rates were considerably elevated and since the Iron Horse Park hazardous waste site may have been a source of asbestos exposure in the past, risk ratios, standardized by age and sex were calculated for 1975-1985 (population data for the 1969-1974 time period was unavailable) to determine whether Billerica residents, 18 years of age and older living within a 1 mile radius of the site were at a greater risk of dying of lung cancer as compared to Billerica residents outside of a 1 mile radius of the site. That is, assuming that persons living within 1 mile of the site are "exposed" and persons living outside of a 1 mile radius are "unexposed".

Block statistics from the 1980 federal census were used to determine the number of persons who lived within a 1 mile radius of the site. A United States Geological Survey (USGS) topographical map was used to help determine population within blocks that were split at the 1 mile border. Households were counted for the whole block using the USGS map and the proportion of the houses lying within the 1 mile border was then applied to the population figure for that block in order to arrive at an estimate of the population for the block. This method was successful in all but two border blocks. Subsequently, since the population for these blocks could not be equitably divided between the "exposed" area and the "unexposed" area, the analysis was performed twice, including and excluding the population in the two blocks. Block statistics are not broken down by sex, therefore the male and female population figures were

also arrived at proportionally. That is: the proportion of females living in census tract 3165 was applied to census blocks within census tract 3165, etc. Block statistics are presented in 3 age categories (<18, 18-64, 65+); since there were no lung cancer deaths in persons under 18 years of age, two age categories were used: 18-64 and 65+. The population outside of the 1 mile radius was determined by subtracting the age and sex specific numbers within the 1 mile radius from the 1980 Billerica population.

Persons who had died of lung cancer during 1975-1985 were categorized as either living within a 1 mile radius of the site or outside of the 1 mile radius according to the address on the death certificate. One male in the 18-64 age category resided near the border and was included within the radius--though his actual address may be just outside.

Essentially, a risk ratio of 1 indicates that the rate of lung cancer mortality is the same in the exposed group as in the unexposed group. A risk ratio of 2 would indicate that the rate of lung cancer mortality is 2 times as high in the exposed group. Conversely, a risk ratio of .50 indicates that the exposed group has 1/2 the risk of lung cancer mortality.

Using these criteria and excluding the 2 border blocks from the population within the "exposed" area (the 1 mile radius), it appears that males age 18-64 living within a 1 mile radius of Iron Horse Park have a risk ratio of 5.8. That is to say that men in this age group are at 5.8 times the risk of dying of lung cancer as men in the same age group outside the one mile radius. Women in this same age group, however, have a risk ratio of 1.3. Men 65 and older have a risk ratio of 0.8. Women age 65 and older have a risk ratio of 3.2. The combined risk ratio for

males and females aged 18-64 is 4.6. The combined risk ratio for individuals 65 and older is 1.3.

With the inclusion of the 2 border blocks the risk ratio for males aged 18-64 is 5.5, for males aged 65 and older the risk ratio is .77. For females aged 18-64 the risk ratio is 1.3. Females aged 65 and older have a risk ratio of 3.0. The combined risk ratio for persons aged 18-64 is 4.0 and for persons over 65 years of age, 1.3. The risk ratios and the 95% confidence intervals for the risk ratios are presented in table 14.

In his book "Occupational Epidemiology" Monson defines 95% confidence intervals: "If a number of 95% confidence intervals are computed, the true (risk ratio) will be expected to lie within 95% of the intervals, assuming that the data are not biased." This means that in 100 studies of this nature the confidence intervals computed around the risk ratio will contain the true relative risk 95 times.

Because there are many potential sources of bias in the calculation of these risk ratios, they should be interpreted with caution. For example, it should be kept in mind that by excluding 2 blocks population data the risk ratio in some cases was somewhat higher than when including them. Therefore, the actual risk ratio values are probably somewhere between the presented values. Including a decedent as part of the "exposed" population who may have resided outside of the 1 mile radius could also bias the results toward a positive finding. Conversely, excluding this individual would bias towards a negative finding. Also, the addresses

used were the addresses on the death certificate and may not be an accurate method of assessing residence (e.g.: the duration of residence is unknown, etc.).

Table 14

Risk Ratios
Lung Cancer Mortality Risk
for
Billerica Residents Living Within 1 Mile of Iron Horse Park

	excluding 2 blocks			including 2 blocks		
	risk ratio	95% confidence limits lower	upper	risk ratio	95% confidence limits lower	upper
Total						
18-64	4.6	2.6	8.0	4.0	2.3	7.0
65+	1.3	0.6	2.7	1.3	0.6	2.5
Males						
18-64	5.8	3.2	10.7	5.5	3.0	10.1
65+	0.8	0.3	2.2	.77	0.3	2.0
Females						
18-64	1.3	0.2	5.9	1.3	0.2	5.6
65+	3.2	1.0	9.5	3.0	0.9	9.0

V. CONCLUSIONS/RECOMMENDATIONS

Because of the findings of excess lung cancer mortality in several areas of the town, and the earlier results of cancer incidence analyses revealing a greater than expected number of cases of mesothelioma, coupled with the indication that persons living near the hazardous waste site may be at a higher risk of lung cancer mortality, the DPH will conduct a phase II follow-up study of lung cancer in Billerica. The follow-up study will address occupational, residential, smoking, and other risk factors that influence the development of lung cancer. This study will better characterize past lung cancer risk in Billerica.

In addition, the DPH has recently received federal monies from the Agency for Toxic Substances and Disease Registry (ATSDR) to allow the DPH to better characterize the potential health risks resulting from environmental contamination at the Iron Horse Park site. This information will prove valuable when assessing past exposures to asbestos and other potentially carcinogenic chemicals.

Because of the well established lifestyle risk factors associated with the cancers that are elevated, the MDPH will work together with the community in establishing programs targeted at the reduction of these risk factors.

Since other cancer mortality rates were elevated, most notably kidney and bladder cancers, DPH will review 1982-1986 cancer incidence data for the sites where noteworthy elevations were found. This activity will be particularly important because of the long latency period for development of the cancers of concern: cancers occurring now could potentially be due

to exposures that occurred 15-40 years ago which is prior to the time the Iron Horse Park site was remediated. This assessment should also help to determine whether elevations in rates are continuing.

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